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SEISMOLOGY.—*Earthquakes associated with the 1934 eruption of Kilauea, Hawaii.*[1] AUSTIN E. JONES, U. S. Geological Survey.
(Communicated by T. A. JAGGAR.)

This paper is essentially a continuation of a previous paper entitled *Earthquakes associated with the 1933 eruption of Mauna Loa, Hawaii,*[2] although a sharp line cannot be drawn between the aftershocks associated with the 1933 eruption of Mauna Loa and the foreshocks of the 1934 eruption of Kilauea. However, because the eruptions of Mauna Loa and Kilauea were the only known eruptions in Hawaii in 1933 and 1934, respectively, the earthquakes for these years are described as being associated in 1933 with the Mauna Loa eruption and in 1934 with the Kilauea eruption.

The same seismograph stations (Table 1) were maintained in 1934 as in 1933 for as long a period as finances permitted.

TABLE 1.—SEISMOGRAPH STATIONS IN HAWAII IN 1934

Name	Symbol	Name	Symbol
Hawaiian Volcano Observatory	V	Hilo[a]	H
Uwekahuna	U	Kealakekua[a]	K
Halemaumau (Pit)	P	Waikii[b]	W

[a] Stations run by volunteers.
[b] Station discontinued October 1934.

These stations were maintained by the U. S. Geological Survey and the Hawaiian Volcano Research Association. The work done by the writer was undertaken as a cooperative project between the U. S. Geological Survey and the University of Hawaii.

The locations of the earthquakes shown in Table 2 and on Figures 1 and 2 were made by the graphical method of Isikawa,[3] using the S-P curves developed in previous studies of the Hawaiian volcanic earthquakes.[4] These previous studies indicate that the following

[1] Published by permission of the Director, U.S. Geological Survey. Received June 19, 1935.
[2] JONES, AUSTIN E. *Earthquakes associated with the 1933 eruption of Mauna Loa.* This JOURNAL 24: 413–418. 1934.
[3] BYERLY, PERRY. Bull. N. R. C. *Physics of the Earth, 6, Seismology,* p. 162.
[4] JONES, AUSTIN E. Hawaiian Travel Times. Bull. S. S. A. 24: no. 1; *A Seismological Study of the Kilauea Eruption 1931–1932.* Univ. of Hawaii research paper no. 9.

TABLE 2.—EARTHQUAKES PRECEDING AND FOLLOWING THE 1934 ERUPTION OF KILAUEA

Map No.	Date	No. of Phases	Lat. N ° ′	Long. W ° ′	Recording stations	Depth	Intensity[d]	Remarks
1	Jan. 2	2?	19 50	155 27	VHW	5	v.f.	Felt in Honomu, Waikii, Kilauea
2	Jan. 6	1	19 30	155 36	P	?	v.f.	Felt in Mokuaweoweo
3	Jan. 7	2	19 23	155 16	VPU	5	v.f.	Not felt; in Kilauea
4	Jan. 7	1	19 23	155 16	VPU	4	v.f.	Not felt; in Kilauea
5	Jan. 9	3	19 09	155 41	VKHW	?	slight	Felt generally, phases confusing
6	Jan. 13	1	19 10	155 10	VKHW	19	slight	Felt generally in Hawaii
7	Jan. 16	1	19 23	155 17	VPU	0	tr.	Not felt, near Kilauea
8	Jan. 19	3	19 13	155 27	VHK	?	feeble	Not felt
8A	Jan. 25	1	19 18	155 22	VPU	10	v.f.	
9	Jan. 30	3	19 30	155 33	VHKW	13	feeble	
10	Feb. 1	3	19 23	155 40	VKHW	0	v.f.	
11	Feb. 9	3	19 18	155 33	VHKW	19	slight	Felt generally, stronger at Kapapala
12	Feb. 19	2	19 26	155 14	VHK	5	slight	Located and felt near Kilauea crater
13	Feb. 24	2	19 40	155 40	KHW	20	feeble	Felt in NE Hawaii
14	Mar. 1	4	19 31	155 31	KHV	14–24	slight	Felt generally, may be shallower
15	Mar. 10	2	19 32	154 48	VH	?	v.f.	Not felt
16	Mar. 10	2	19 20	155 10	VUH	8	v.f.	Not felt
17	Mar. 11	2	19 24	155 03	VP	?	tr.	Very doubtful location
18	Mar. 13	2	19 26	155 14	VPU	?	v.f.	Doubtful location
19	Mar. 18	2	19 24	155 15	VPU	1	v.f.	
20	Mar. 24	2	19 21	155 11	VP	?	v.f.	Located on a line,[c] at no. 16
21	Mar. 29	3	18 58	155 59	VKH	14	v.f.	On Mauna Loa SW rift
22	Mar. 30	2	19 22	155 11	VP	?	v.f.	
23	Apr. 3	4	19 44	154 38	VH	?	v.f.	Probably shallow. East of Hawaii
24	Apr. 6	2	19 30	155 16	VUH	1	v.f.	
25	Apr. 9	3	20 04	155 51	VKH	?	v.f.	Felt in Kohala
26	Apr. 9	4	20 11	155 28	VKH?	?	feeble	Felt in Kohala
27	Apr. 11	3	19 20	154 50	VH	?	v.f.	Not felt
28	Apr. 12	1	19 24	155 16	VPU	2	v.f.	Not felt in Kilauea
29	Apr. 13	3	19 37	155 37	VHK	0–5?	feeble	Not felt
30	Apr. 14	5	19 37	154 47	VKH	?	slight	Felt in Hilo and Olaa
31	Apr. 15	1	19 24	155 11	VPU	?	v.f.	Felt near Kilauea
31A	Apr. 17	3	19 21	155 03	VH	?	v.f.	Not felt
32	Apr. 24	2	19 14	155 46	VK	?	v.f.	Not felt
33	Apr. 30	1	19 44	154 30	VH	?	tr.	Probably deep
34	May 9	1	19 27	155 30	KHP	42	v.f.	
35	May 10	2	19 39	155 23	VHK	22	moderate	Felt generally; with alarm in Hakalau; slight damage in Hilo
								Felt on the island of Maui 180 km. distant
36	May 10	3	19 38	155 24	VKH	44?	v.f.	Aftershock felt in Hakalau, may be shallower
37	May 10	3	19 18	155 20	VKH	18	feeble	Felt at Kilauea and in Hilo
38	May 13	3	19 29	155 29	VKH	9	slight	Felt; location agrees with angle from V
39	May 13	2	19 18	155 27	VKH	5	feeble	Felt; location agrees with V. and K. angles
40	May 16	1	19 10	155 30	VK	?	v.f.	Focus deep?
40A	May 22	1	19 24	155 16	VPU	0	v.f.	In Kilauea crater
41	May 30	3	19 47	156 10	VK	?	tr.	
42	June 5	3	19 38	155 12	VKH	11	v.f.	Larger record at Hilo anomolous (S–P)
43	June 15	3	19 31	155 23	VKH	?	v.f.	
44	June 25	3	19 34	155 13	VKH	19	v.f.	
45	June 26	2	19 15	155 07	VKH	24	moderate	Felt generally
46	June 27	2	20 00	155 15	VH	?	v.f.	Felt in Honokaa
47	July 5	2	19 21	155 37	VHK	24	v.f.	Tremor at W
48	July 5	1	19 33	155 23	VHK	3	v.f.	
49	July 20	2	19 24	155 16	VKHPU	1	slight	Felt strongly near Pit
50	July 25	5	19 17	155 25	VHK	34	v.f.	Felt at Kapapala. First location at no. 64 may be better, 7 km. deep
51	July 30	3	19 40	155 50	VK	?	v.f.	Not felt in Kona
52	July 30	2	19 21	155 12	VPU	7	v.f.	At no. 16
53	July 30	1	19 23	155 17	VPU	3	v.f.	
54	July 31	1	19 25	155 15	VHPU	9	v.f.	
55	Aug. 7	3	19 32	155 31	VKH	?	v.f.	Distance circles fail to intersect
56	Aug. 11	2	19 32	155 32	VKH	30	v.f.	Felt in Hilo
57	Aug. 16	1	19 32	155 16	VKH	5	slight	Felt in Hilo and Honomu
58	Aug. 25	1	19 25	155 16	VPU	2	v.f.	Kilauea crater
59	Aug. 28	2	19 25	155 16	VP	?	v.f.	Felt and located near or in Kilauea crater
60	Sept. 6	2	19 25	155 17	VPU	0	slight	Awakened residents near Kilauea crater
61	Sept. 9	1?	19 24	155 17	VPU	0	feeble	Outbreak of lava in Pit
62	Sept. 17	2	19 06	155 16	VHK	20	feeble	Felt in Hilo and Honomu
63	Sept. 22	2	19 15	155 20	VHK	11	feeble	Two of seven felt at Kapapala

TABLE 2. (*Continued*)

Map No.	Date	No. of Phases	Lat. N ° ′	Long. W ° ′	Recording stations	Depth	Intensity[d]	Remarks
64	Sept. 23	1	19 15	155 27	VKH	24	v.f.	
65	Oct. 3	2	19 19	155 27	VKH	31	v.f.	At no. 39
65A	Oct. 12	1	20 10	155 30	V?K?H	120?	tr.	
65B	Oct. 12	—	20 00	155 30	no	?	tr.?	Felt in Honokaa
66	Oct. 13	2	19 23	155 28	VKH	60	moderate	Felt generally
67	Oct. 18	2	19 31	155 39	VKH	58	feeble	Felt generally
68	Oct. 18	1	19 31	155 39	VHK	?	v.f.	Aftershock at no. 67
69	Oct. 27	1	19 33	155 32	VKH	45	feeble	Felt near Kilauea
70	Nov. 12	2	19 12	155 22	VH	?	v.f.	

[*] An earthquake recorded on two stations only can be located indefinitely on a line, unless directions are used. Distances from three stations may define a point.

[d] Increasing intensity on the Hawaiian volcanic scale, starting with the least and comparing with the Rossi-Forel scale in Roman numerals, is, tremor, I; very feeble, I; feeble, I; slight, II; moderate, III; and strong IV.

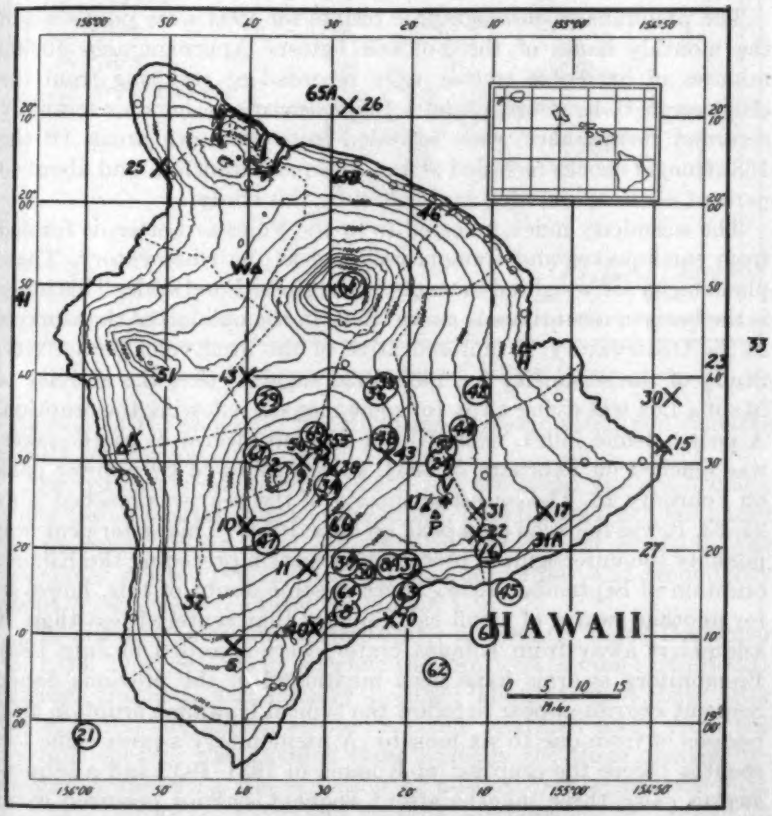


Fig. 1.—Earthquake epicenters in Hawaii.

equations, although not perfect, for very near and high focus earthquakes are better.

$$S_1\text{–}P_1 \;::\; t_1 \;::\; 0.333\Delta$$
$$S_2\text{–}P_2 \;::\; t_2 \;::\; 0.125\text{–}0.245\Delta$$
$$S_3\text{–}P_3 \;::\; t_3 \;::\; 0.20\text{–}0.217\Delta$$

These curves supersede the t_g equation used in the 1933 study. The t^* and t_n curves are still considered applicable. Because these curves were derived from the study of earthquakes that probably occurred within eight kilometers of the surface, it is doubtful if they give more than approximate data when used for finding the deeper foci, although the figures obtained should be roughly proportional.

The preliminary seismographic results for 1934 were published in the monthly issues of the Volcano Letter.[5] Approximately 40,000 minutes of harmonic tremor were recorded as resulting from the eruption in Halemaumau, and 1,400 *spasmodic tremors*, or minutely recorded earthquakes, were recorded from unknown areas. Of the 168 stronger shocks recorded about 25 percent were felt, and about 40 percent of those recorded are located by this study.

The seismicity index, referred to in the Volcano Letter, is formed from earthquakes and tremors recorded at the Observatory. These phenomena are weighted in terms of the Rossi-Forel scale. This index is the basis of a continuous curve, that, in the opinion of the workers at the Observatory, is representative of the local volcanic activity. Study of the seismicity for 1933–1934 suggests that the activity of Mauna Loa was dying away for some months following the eruption. A peak seismic index, caused by a sequent swarm of earthquakes, was reached on February 5, 1934. It was followed by a lower peak on February 26. The lowest seismicity of the year was reached May 21–23. It was followed by a peak on June 10–17. This latter peak was possibly the unrecognized premonitory swarm preceding the Kilauea eruption of September 1934. There is some doubt of this, however, for another swarm of small earthquakes that centered less than 16 kilometers away from Kilauea crater, were recorded in July 1933. Premonitory swarms have been mentioned in the previous paper. Sequent swarms appear to follow the typical Hawaiian eruption after periods of from one to six months. A premonitory swarm came two months before the eruption of Kilauea in 1931–1932 and a sequent swarm came three months after.[6] Sequent swarms occurred seven

[5] Published by the Hawaiian Volcano Observatory, Hawaii National Park, T. H.
[6] JONES, A. E. *A Seismologic Study*. Op. cit.

weeks after the 1933 eruption and 11 weeks after the 1934 eruption.

The map (Fig. 1) shows the location of epicenters. Although there is considerable doubt as to the accuracy of the locations, it is thought that the true epicenters may lie inside the circles shown on the map. The larger scale map of Kilauea crater (Fig. 2) shows more accurately the locations near the crater.

Table 2 contains the map number, the date of occurrence, the number of *P* and *S* phases recognized in the Observatory record, the latitude and longitude, the initials of the stations used in locating the epicenter and focus, the apparent depth of focus in kilometers, the

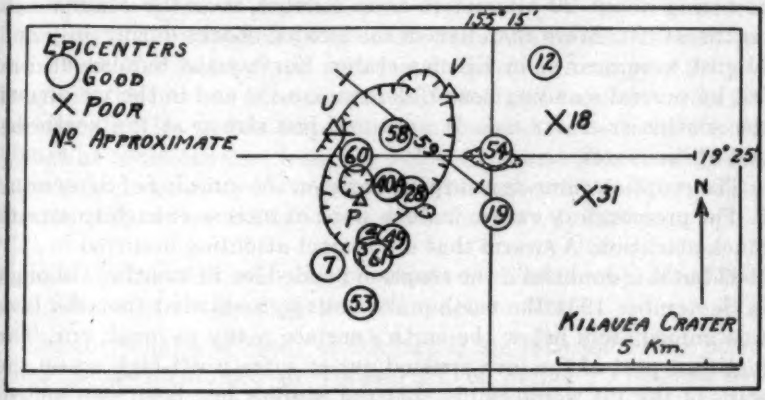


Fig. 2.—Earthquake epicenters at Kilauea Crater.

intensity of the shock on the Hawaiian volcanic scale, and remarks mostly on macroseismic data.

Approximately one-seventh of the foci are under the sea, usually under the submarine slopes of the island. Less than a tenth fall under the quiescent volcanoes of Mauna Kea, Kohala and Hualalai. The remainder cluster primarily about Kilauea crater and secondarily about Mokuaweoweo crater on Mauna Loa.

The eruption in Mokuaweoweo crater apparently ended December 18, 1933. The previous paper gave the locations of nine earthquakes between that date and January 1, 1934.[7] The statement that "after the eruption the known seismic activity migrated away from the volcanic center" was violated three times in the three months immediately following the cessation of outflow (see epicenters 2, 9, and 14). During the next three months, earthquakes 29, 34, and 38

[7] JONES, AUSTIN E. Op. cit.

occurred. Although they are not close to the crater of Mokuaweoweo, they, with 10, are definitely Mauna Loa shocks. It is believed that they are due to subsidence of the mountain, caused by withdrawal of the lava within.

The seismicity peak of June 10–17 was composed of a swarm of 102 spasmodic tremors. This seismicity peak later appeared to be premonitory in character, though it was not recognized as such at the time. Spasmodic tremors are very infrequently located, but by a process of elimination it appears that they often occur in the Kilauea area. The located earthquakes of about this time were occurring about 20 kilometers from Kilauea near the Mauna Loa northeast rift. More than half of the located shocks during July and August were near or in Kilauea crater. Earthquake number 49 was felt by several standing near Halemaumau Pit and in the vicinity of the southwest crater rim. It appeared less strong at the northeast end of the crater.

The eruption came as a surprise early on the morning of September 6. The premonitory swarm in June was not intense enough to attract much attention. A swarm that did attract attention occurred in July 1933 but it is doubtful if the eruption pended for 14 months; although in September 1934 the earthquake activity indicated that the lava was immediately below the earth's surface ready to break out. The fact that part of the lava spurted out of a fresh rift high up on the walls of the Pit would imply that the conduit had been well sealed.

Study of the tilt as measured by the seismographs at the Observatory and at Halemaumau Pit gave some qualifying facts. The observatory records also show that the tilt was to the northeast, or away from the crater, for some time prior to the outbreak. This is not significant for at that time of year the change in the annual tilt is usually to the northeast. It was noticed that the year's accumulated tilt, compared with the same period in 1933, was to the northeast.[8]

Study of the Halemaumau seismogram showed that there was considerable southwest tilt about 12 hours before the outbreak, that is, away from the crater at that point. Two and a half hours before the outbreak the first small shock was recorded. It was followed by several others, none of them being over two kilometers distant. They were accompanied by a stronger west tilt that soon had the E-W seismograph pen in its limiting position. At 2:21 A.M., 20 minutes before the outbreak of lava the slight earthquake, located at 60, awakened most of the people living on the rim of Kilauea crater.

[8] Volcano Letter, August, 1934.

A few more unlocated and very feeble shocks were recorded before the final shock occurred at 2:44 A.M. So far as known this last shock, located at 61, was coincident with the flowing of the lava. In less than a minute the earthquake coda had faded into harmonic tremor that continued to record for a month. The maximum ground amplitudes at the Halemaumau seismograph were approximately 80 to 100 microns during the first two hours whereas at the Observatory they were about 50 microns; the period remained at 0.6 second. The illustrations of the seismograms made during an eruption of Vesuvius[9] shows a harmonic tremor that is similar to that recorded during an eruption of Kilauea.

During the eruption the four located earthquakes were south and southwest of Kilauea crater and deeper than the average. After the eruption the located shocks were more scattered and even deeper. As after the Mauna Loa eruption, the known seismic activity was for a time at some distance from the volcanic center. Few earthquakes were recorded during November and December 1934. The peak of the sequent swarm did not occur until January 4, 1935.

CHEMISTRY.—*A new chloroarsenate of calcium.*[1] C. M. SMITH, Bureau of Entomology and Plant Quarantine.

Chloroarsenates of many of the metals are reported in the literature. Those mentioned in Volume IX of Mellor's *Comprehensive treatise on inorganic and theoretical chemistry* include two compounds of calcium, namely $Ca(CaCl)AsO_4$ and $Ca_4(CaCl)(AsO_4)_3$. The first has been reported as having been made only by fusion, and the latter both by fusion and by heating the reacting chemicals with water in sealed tubes.

When the author undertook a study of calcium arsenate several years ago, he considered the possibility of the formation of chloroarsenates of calcium in aqueous solutions at ordinary pressure in a manner similar to the formation of mimetite from dilead arsenate and soluble chlorides demonstrated by McDonnell and Smith (Amer. Jour. Sci. **42**: 139–145, Aug. 1916). In the effort to produce such compounds, dicalcium arsenate, $CaHAsO_4 \cdot H_2O$, was heated on the steam bath with concentrated solutions of calcium chloride. None of the experiments produced either of the compounds described in the literature, but from several of them there was obtained a well-crystallized compound with a composition corresponding to the

[9] SIGNORE, FRANCESCO. Bulletin Volcanologique 19–22: 48. 1929.
[1] Received May 27, 1935.

formula $(CaCl)_2HAsO_4 \cdot 2H_2O$. The experiment which produced the best specimen of this material was performed as follows:

Fifty g of anhydrous $CaCl_2$ was dissolved in 50 cc H_2O, and 5 cc concentrated HCl added to destroy the carbonate and hydroxide which were present. Then dicalcium arsenate, $CaHAsO_4 \cdot H_2O$, was added to saturation and the mixture set on the steam bath. In the course of 11 days a crystalline precipitate formed. At the end of that time a large volume of alcohol (in which $CaCl_2$ is easily soluble) was added to prevent hydrolysis of the solid material and the latter was filtered on a Büchner funnel, washed with alcohol, and dried at 110° for one-half hour, at the end of which time the alcohol had been completely expelled.

Analysis of this product gave the following results:

	Theory for $(CaCl)_2HAsO_4 \cdot 2H_2O$	Found
	Percent	Percent
Ca	24.50	24.30
$HAsO_4$	42.79	42.54
Cl	21.69	21.55
H_2O of cryst.	11.02	11.61 by diff.
	100.00	100.00

Examination with the polarizing microscope showed an apparently uniform product consisting of well-formed crystals with parallel extinction, lying almost invariably perpendicular to the acute bisectrix. The optic angle is about 120° in air, and the negative character is well marked. The crystals are very probably orthorhombic. There appears to be no doubt that this is a definite chemical individual. The formula assigned to it is empirical, and was adopted merely as a means of relating the compound to the normal calcium arsenates.

BOTANY.—*Three new species of* Aphelandra *from Colombia.*[1] E. C. LEONARD, National Museum. (Communicated by WILLIAM R. MAXON.)

The new species described in this paper are based on material collected in the region of Mt. Chapón, Department of Boyacá, Colombia, by A. E. Lawrance. The type specimens of two are in the her-

[1] Published by permission of the Secretary of the Smithsonian Institution. Received June 11, 1935.

barium of the Royal Botanic Gardens, Kew; the other is in the U. S. National Herbarium.

Aphelandra lawranceae Leonard, sp. nov.

Herba perennis, suffruticosa; folia basi spicae subrosulatim conferta, anguste oblongo-elliptica, apice acuta, basin versus sensim angustata et in petiolum decurrentia, glabra, subtus purpurea; spicae terminales, simplices, sessiles; bracteae imbricatae, oblongo-lanceolatae, acuminatae vel acutae,

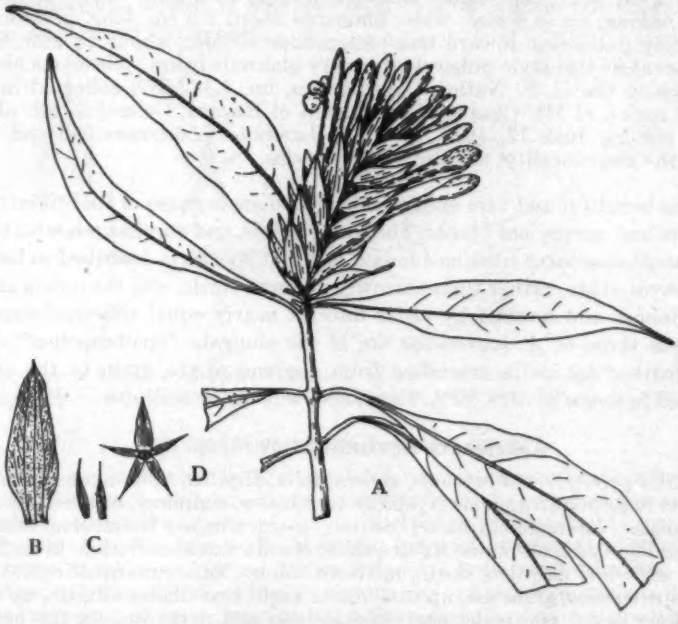


Fig. 1.—*Aphelandra lawranceae* Leonard, sp. nov. A, plant, one-half nat. size; B, flower bract; C, bractlets; D, calyx spread to show segments. (B, C, D, nat. size.)

integerrimae, puberulentae, ciliatae; bracteolae et calycis laciniae striatae, puberulentae; corolla coccinea, puberula, labio superiore integro, inferiore trilobo, lobis subaequalibus.

Suffrutescent, up to 12 cm. high; stems terete, glabrous, more or less verrucose; leaves opposite, the internodes 1.5 to 5 cm. long, or often 4 or 5 pairs crowded at the base of the spike, forming a rosette; leaf blades narrowly oblong-elliptic, up to 17 cm. long and 3 cm. wide, gradually narrowed at base and decurrent on the petiole, acuminate at apex, ending in a blunt tip, entire or undulate, both surfaces glabrous, the under surface often dark mauve; petioles up to 2 cm. long; spike terminal, up to 7 cm. long and 2 cm. in diameter, the rachis puberulent; bracts rather closely imbricate, erect-spreading, oblong-lanceolate, up to 2.5 cm. long and 9 mm. wide (narrowed to 5 mm. at base), abruptly acuminate to acute at apex, entire, puber-

ulent, ciliate; bractlets narrowly lanceolate, up to 9 mm. long and 1.5 mm. wide, 1-nerved, striate, puberulent, some of the hairs glandular; calyx segments subequal, about 9 mm. long, narrowly lanceolate, acuminate, the posterior one 3 mm. wide, minutely bidentate at apex, the anterior pair 1.7 mm. wide, the lateral pair 1.5 mm. wide, all striate, puberulent toward tip (glandular and eglandular hairs mixed); corolla up to 6.5 cm. long, brilliant red, finely pubescent, the tube gradually enlarged from 3 mm. at base to 5 mm. at throat, the upper lip entire, oblong, about 15 mm. long and 6 mm. wide, the lower 3-lobed, the lobes subequal or the lateral slightly shorter, up to 2 cm. long, the middle lobe obovate, up to 8 mm. wide, the lateral lobes oblong, up to 6 mm. wide; filaments about 3.5 cm. long, glabrous or minutely pubescent toward base; staminode slender, about 13 mm. long, pubescent at tip; style puberulent; ovary glabrous below, pilosulous above.

Type in the U. S. National Herbarium, no. 1,482,539, collected in the forest region of Mt. Chapón, Department of Boyacá, Colombia, alt. about 1650 meters, June 17, 1932, by A. E. Lawrance. *Lawrance* 243 and 252, from the same locality, are also of this species.

This beautiful and rare species is conspicuous because of its brilliant red flowers and purple leaf blades. The spike, bracts, and corollas resemble those of *Encephalosphaera vitellina* Lindau, but that species is described as having the leaves ovate, rather than narrowly oblong-elliptic, and the pollen grains are globose and marked by clefts into six nearly equal spherical squares, whereas those of *A. lawranceae* are of the elongate "spaltenpollen" type, i.e., marked by clefts extending from one end of the grain to the other. Named in honor of Mrs. E. A. Lawrance, wife of the collector.

Aphelandra alexandri Leonard, sp. nov.

Herba perennis, suffruticosa, glabra; folia elliptica, apice acuminata, basi sensim in petiolum angustata; spicae terminales, simplices, sessiles; bracteae imbricatae, oblongo-ellipticae, acutae, integerrimae; bracteolae lineares; calycis laciniae lanceolatae subaequales; corolla extus scarlatina, intus flava, labio superiore elliptico, acuto, inferiore trilobo, lobis subaequalibus.

Suffrutescent, glabrous, up to 1 meter high; leaf blades elliptic, up to 15 cm. long and 5 cm. wide, narrowed at base and decurrent on the petiole, acuminate, ending in a blunt point, entire or undulate, green, the costa and lateral veins (9 or 10 on each side) rather prominent; petioles up to 3 cm. long, winged; spikes terminal, sessile, up to 10 cm. long and 2 cm. in diameter, the bracts rather closely imbricate, erect or erect-spreading, oblong-elliptic, up to 18 mm. long and 3 mm. wide at base and 1 cm. wide at middle, acute at apex, subchartaceous, veiny; bractlets linear-subulate, 1 mm. wide at base, striate; calyx segments lanceolate, subequal, 8 or 9 mm. long, bearing at base triangular calluses (these conspicuous on the outside), the posterior segment oblong, 2.5 mm. wide, 2- or 3-toothed at tip, the anterior pair (1.5 mm. wide) and the lateral pair (1 mm. wide) narrowly lance-attenuate; corolla about 6 cm. long, brilliant red without, yellow within, glabrous except the lips, these minutely pruinose within; tube gradually enlarged from 4 mm. in diameter at base to 6 mm. at mouth, the upper lip elliptic, about 2 cm. long and 8 mm. wide, acute, the lower lip 3-lobed, the lobes subequal, oblong-obovate, about 2 cm. long, 7 to 8.5 mm. wide near middle, acute or acutish at apex; staminode not evident in flower examined;

filaments and style glabrous; pollen grains elongate, muricate, of the "spaltenpollen" type.

Type in the Kew Herbarium, collected in the region of Mt. Chapón, Department of Boyacá, Colombia, Feb. 4, 1933, by A. E. Lawrance (no. 601).

Related to *A. lawranceae*, which it resembles closely in many respects. The bracts and corolla are strictly glabrous, however, whereas in *A. lawranceae* the bracts are densely puberulent and the corolla is pubescent. Furthermore the flowers of this species are yellow within, but those of *A. lawranceae* are red throughout.

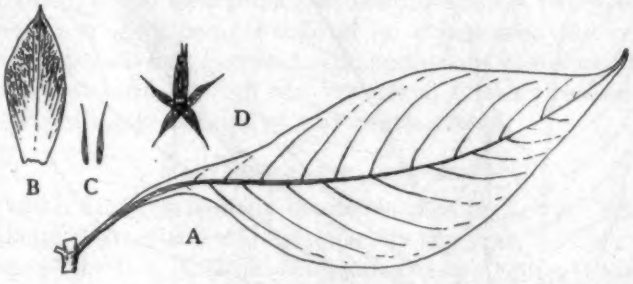


Fig. 2.—*Aphelandra alexandri* Leonard, sp. nov. A, leaf, one-half nat. size; B, flower bract; C, bractlets; D, calyx spread to show segments. (B, C, D, nat. size.)

Aphelandra parviflora Leonard, sp. nov.

Herba; caulis simplex, basi procumbens, nodis infimis radicans, adpresso-pilosus; folia pauca, oblonga, apice acuta vel obtusa, in petiolum decurrenti-angustata, subglabra, costa et nervis lateralibus strigosis; spica gracilis, pedunculis elongatis, fere nudis, strigosis; bracteae erecto-patentes, ellipticae, grosse spinuloso-serratae, parum strigosae; bracteolae subulatae, subhyalinae; calycis laciniae oblongo-acuminatae, subaequales, glabrae (marginibus exceptis), striatae; corolla parva, flava, minute pilosa, labio superiore bilobo, inferiore trilobo, lobis orbiculatis.

Herbaceous, the stem 10 cm. high or more, ascending, rooting at the lowermost nodes, strigose; leaves usually several, the blades oblong, up to 25 cm. long and 18 cm. wide, elliptic, obtuse or obtusish at apex, cuneate at base and decurrent on the petioles, entire or undulate, purple beneath, sparingly strigillose, glabrescent except for costa and lateral nerves (15 to 18 pairs), these strigose; petioles slender, up to 6 cm. long, strigose; spikes slender, up to 13 cm. long, about 1 cm. in diameter, the peduncles up to 12 cm. long, strigose, bearing a pair of bractlike leaves about 2 cm. below the base of the spike; bracts rather loosely imbricate, erect-spreading, elliptic, 1 cm. long, 3 to 4 mm. wide, acuminate, ending in an obtuse tip, firm, veiny, sparingly strigose, with several erect-spreading narrow teeth up to 1.5 mm. long on each side; bractlets lance-subulate, 3.5 mm. long, 1 mm. wide at base, thin, subhyaline, nerved; calyx segments narrowly oblong, acuminate, subequal, 5 to 6 mm. long, the posterior one 2 mm. wide, the anterior pair 1.5 mm. wide, and the lateral pair 1 mm. wide, subhyaline, striate-nerved, minutely

glandular-ciliolate; corolla yellow, 1 to 1.5 cm. long, obliquely hypocrateriform, minutely and sparingly pubescent, the tube 1 mm. broad at base, about 4 mm. broad at mouth; limb about 8 mm. broad, the lips equal, the upper one 2-lobed, 5.5 mm. broad, the lower 3-lobed, the lobes orbicular, 4.5 mm. in diameter; stamens included.

Fig. 3.—*Aphelandra parviflora* Leonard, sp. nov. A, plant, one-half nat. size; B, flower bract; C, bractlets; D, calyx spread to show segments. (B, C, D, twice nat. size.)

Type in the Kew Herbarium, collected in the region of Mt. Chapón, Department of Boyacá, Colombia, June 10, 1932, by A. E. Lawrance (no. 201). Represented also by *Lawrance* 291, from the same locality.

Well marked by its purple leaves and loose, slender pedunculate spikes of small flowers.

PALEOBOTANY.—*Some fossil conifers from Maryland and North Dakota.*[1] ROLAND W. BROWN, U.S. Geological Survey.

Fossil cones and other remains, resembling or suggesting those of living coniferous species, are not rare in American Cretaceous deposits. The fact that many of these cones are found detached, although often associated in the same strata with foliage and fossil wood, is a circumstance that has resulted, perhaps unavoidably, in the description of numerous species, many of which, unfortunately, are based upon very fragmentary types whose characters, especially when figured, are so misleading that identification of new specimens by comparison with them, is difficult for experienced and inexperienced students alike. It is considered appropriate, therefore, in looking toward a clarification of this condition, to describe and figure such new and better material as may be discovered.

MARYLAND FOSSIL CONIFERS

The writer's interest in an unreported locality for Lower Cretaceous fossil plants in Maryland was enlisted early this year (1935) by James H. Benn, of the U.S. National Museum, and two young Washington collectors, Floyd A. Rapp and Douglas Graham, who found in deposits there a large amount of fossil wood and several well-preserved cones. This locality includes about 1500 feet along the bank of the Northwest Branch of the Anacostia River, beginning at the new bridge on Queen's Chapel Road, three-fourths mile beyond the District of Columbia line, and running northwestward upstream. The general geologic section and situation of this exposure are as sketched in Figure 13. The Northwest Branch, in that part of its course, has cut a channel 6 to 10 feet below the floodplain surface through comparatively young alluvium composed of sands, sandy clays, and gravels, into slightly southeastwardly dipping Lower Cretaceous sediments consisting of bluish sandy clays, crossbedded sands, and infrequent lenses of fragmental material cemented by iron oxide. That the latter are Lower Cretaceous strata is clearly demonstrated from the fact that a little more than a mile west of this locality the igneous and metamorphic basement complex emerges, and since its eroded surface, upon which the Lower Cretaceous deposits rest, slopes seaward at the rate of 75 to 100 feet per mile, it follows that the strata outcropping at the locality on Northwest Branch are about 125 feet above that unconformity and belong to the Lower Cretaceous

[1] Published by permission of the Director, U.S. Geological Survey. Received July 24, 1935.

Potomac group, for the total thickness of that group at nearby points in the District of Columbia and Maryland reaches approximately 600 feet.

At the bottom of the sketch the waters of the Northwest Branch are shown washing the Cretaceous outcrop and its embedded fossil wood. These prostrate logs, some measuring nearly 6 feet in diameter, are much flattened and are jumbled or matted together in a manner suggesting driftwood. They are now lignite, jet-black in color, with occasional impregnations and fillings of marcasite. The wood, in many instances, shows well-preserved cellular structure that indi-

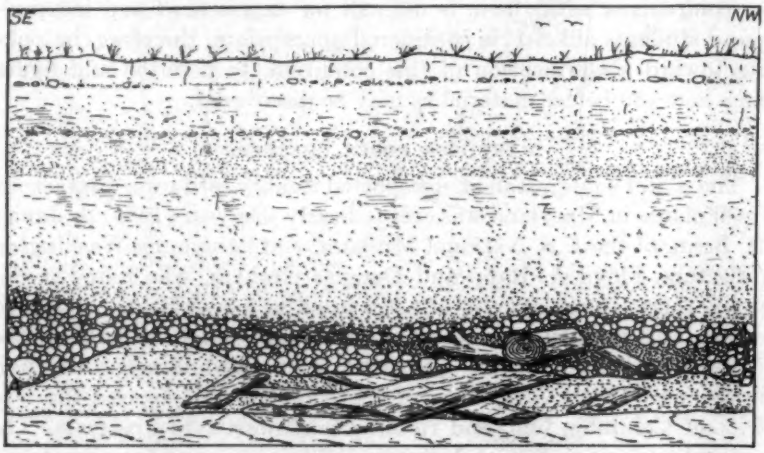


Fig. 13.—Sketch of geologic section, 8 feet deep, along Northwest Branch of Anacostia River, Md. The irregular line A—B marks the great unconformity between the Lower Cretaceous and young alluvial deposits.

cates its coniferous relationship alluded to in the name, *Cupressinoxylon wardi*, given it by F. H. Knowlton in 1889. Only rarely may cones, such as those to be described below, be found among these wood remains.

It is conjectured that if this Cretaceous deposit could be uncovered over a large area thousands of logs might be revealed, simulating in some respects but on a smaller scale, a sight like that in the Petrified Forest of Arizona. However, such an exposure of this lignite would not persist intact for many days because on drying the wood checks and disintegrates rapidly. To preserve cones and wood of this kind it is necessary to remove the absorbed water from them but they must be prevented from drying in air. This may be accomplished by dehy-

drating the specimens for several hours in 95 per cent alcohol and then shellacking them with a thin solution of celloidin in acetone or some similar preparation.

The irregular line A—B in Figure 13 represents the eroded, channeled surface of the Cretaceous strata upon which rest 6 feet, more or less, of younger alluvium beginning at the bottom with a foot or more of coarse gravel and sand and grading upward through two sequences of sand, sandy clay and silt, to top soil. In the gravel at the base is a lens of sand and clay from which by sieving with a fine screen there have been recovered a number of decalcified fresh-water mussels (*Elliptio complanatus*), insect fragments including four beetles (*Calosoma scrutator, Chlaenius impunctifrons, Dicaelus* sp., *Euphoria fulgida*), unflattened, little-altered logs and branches of white pine (*Pinus strobus*), northern hemlock (*Tsuga canadensis*), and white oak (*Quercus alba*), and 35 species of fruits and seeds (*Pinus strobus, Tsuga canadensis, Sparganium androcladum, Potamogeton nuttallii, Carex* sp., *Quercus alba, Q. rubra, Q. phellos, Corylus americana, Carpinus caroliniana, Hicoria glabra, H. ovata, Juglans cinerea, Myrica carolinensis, Polygonum* sp., *P. hydropiperoides, Liriodendron tulipifera, Tilia americana, Staphylea trifolia, Platanus occidentalis, Prunus serotina, Rubus* sp., *Phytolacca decandra, Claytonia virginica, Sassafras variifolium, Impatiens biflora, Rhus glabra, Vitis* sp., *Sambucus canadensis, Viburnum acerifolium, V. prunifolium, Nyssa sylvatica, Cornus amomum, C. florida, C. paniculata*). Of these 35 species, probably all but two, northern hemlock and shagbark hickory, may be found living in the basin of the Northwest Branch today. The nearest native hemlocks are in the vicinity of Occoquan and Great Falls, Virginia, and these appear to be relict stands abandoned when the species kept pace northward with the receding cool climatic conditions accompanying the dissipation of the last Pleistocene ice sheet. Although the writer has seen no shagbark hickories along the Northwest Branch it is possible there may be a few scattered trees in the upper reaches of the basin.

This collection of relatively recent material will remind those interested in the younger deposits of the District of Columbia and vicinity of the remains taken from the excavations for the Mayflower Hotel[2] and Government Printing Office.[3] The significant species in those collections was the bald cypress (*Taxodium distichum*) which is not

[2] This JOURNAL 14: 1–41. 1924.

[3] BERRY, E. W. *New occurrences of Pleistocene plants in the District of Columbia.* This JOURNAL 23: 1–25. 1933.

present in the collection from the Northwest Branch. Conversely, hemlock and shagbark hickory are absent from those collections; but the Printing Office collection is nevertheless more closely comparable to that from the Northwest Branch than is that from the Mayflower site, which is regarded as representing a flora adapted to slightly warmer, or in some way, more congenial, climatic conditions than those obtaining at present. The altitude of the deposit in the Mayflower Hotel excavation is between 40 and 60 feet; that at the Printing Office, 20 feet; and that on the Northwest Branch, between 25 and 30 feet above sea level. Because of these respective elevations the deposit at the Mayflower site is considered as belonging to the Wicomico terrace stage of the mid-Pleistocene, and the deposit at the Printing Office to the Pamlico terrace stage of the late Pleistocene. On this basis the deposits on the Northwest Branch, if they are terrace sediments, which is not proved, should be assigned to the Pamlico or to the transition between Talbot and Pamlico. The evidence from the organic remains is not strictly conclusive. The state of preservation of the remains is about the same at all these localities. The mussels and beetles are found in the Anacostia River region today; and so far as the plants are concerned, the only positive statement that can be made is that the deposits antedate the disappearance of northern hemlock from that basin.

It is worth noting that both the Cretaceous and younger driftwood were very likely accumulated in the same manner, but at an interval of about 125,000,000 years, represented in the unconformity A—B. During the passage of that unimaginably long period of time the flowering plants (angiosperms) evolved from their primitive Cretaceous ancestors and gradually displaced in dominance the ferns, cycads, and conifers that clothed the land surface of this part of the country when these Lower Cretaceous sediments were deposited.

The species of cones from the Cretaceous strata are as follows:

Abietites macrocarpus Fontaine Fig. 12

Abietites macrocarpus Fontaine. U.S. Geol. Survey, Mon. 15: 262, pl. 132, fig. 7. 1890.—Berry, E. W. *Lower Cretaceous.* Md. Geol. Survey, p. 405, pl. 67, figs. 1–4. 1911.

Cone, 14.5 cm. long, 2.2 cm. in diameter, with numerous, imbricated, thin, striated, persistent scales, having rounded or emarginate upper margins. Jet-black and lignified.

The type of this species described by Fontaine from Lower Cretaceous strata at Dutch Gap Canal on the James River, Virginia, is a fragmentary longitudinal section of a narrow, elongated cone with broken scales. The present specimen exhibits the characters of the type, so far as those features

can be determined, but being complete and well-preserved, is figured here as a more readily recognizable typical example of the species. That the species is a primitive *Abies*, as the name implies, may well be doubted, because, if judged by the nature of cones from living species of *Abies*, the scales should not be persistent long after maturity. *Piceites* might be a better reference than *Abietites*. Unfortunately no foliage was found with this cone, nor were seeds present between the scales. Evidently the cone had matured, shed its seeds, and fallen from the tree into the water that carried it to the site of entombment and lignification. Confusion of this species with *Pinus*, especially the white pine (*Pinus strobus*), whose long, narrow cones resemble the fossil, is unnecessary because the cone scales of *P. strobus* are distinctly acute and are tipped with round, blunt, resinous scars or points.

Figured specimen in the U.S. National Museum.

Cedrites primevus Brown, n. gen. and n. sp. Fig. 11

Cone, 10.5 cm. long, 4 cm. in diameter, narrowly elliptic in shape, with truncated apex. Scales relatively few, large, imbricated, broadly rounded, coarsely and sparsely striated, apparently persistent, with entire margins.

The figure reproduced here is that of a plaster cast made from the fossil which is a hollow mold or impression left in the rock matrix by the original cone, no remains of which were recovered with the impression. Choice of *Cedrites* as a name for this species should only be regarded as suggestive rather than as indicative of its botanic relationship. This species is three times larger and has fewer scales than that called *Cedrus leei* (Fontaine) Berry,[4] from Lower Cretaceous strata at Baltimore, Maryland.

Type in the U.S. National Museum.

Piceites cretaceus Brown, n. sp. Fig. 8

Cones, 3.5 cm. long, 1.5 cm. in diameter, elliptic in shape, with blunt apex and cuneate base. Scales numerous, imbricated, rounded, finely striated, persistent, with entire margins. Jet-black and lignified.

Five specimens of this species are now in the National Museum collections. The fact that they are of uniform size appears to indicate that they represent a well-defined species different from any other so far described from Lower Cretaceous strata. The reference of the species to *Piceites* is based principally upon the rather striking resemblance of these cones to those of some species of *Picea*, particularly the white spruce (*P. canadensis*) of the northern United States. The fossil species called *Pityites* (*Pinites*) *solmsi* Seward[5] from the Lower Cretaceous of England, is not unlike this species. It seems reasonable to expect that a primitive predecessor of *Picea* should have been present in these early Cretaceous floras.

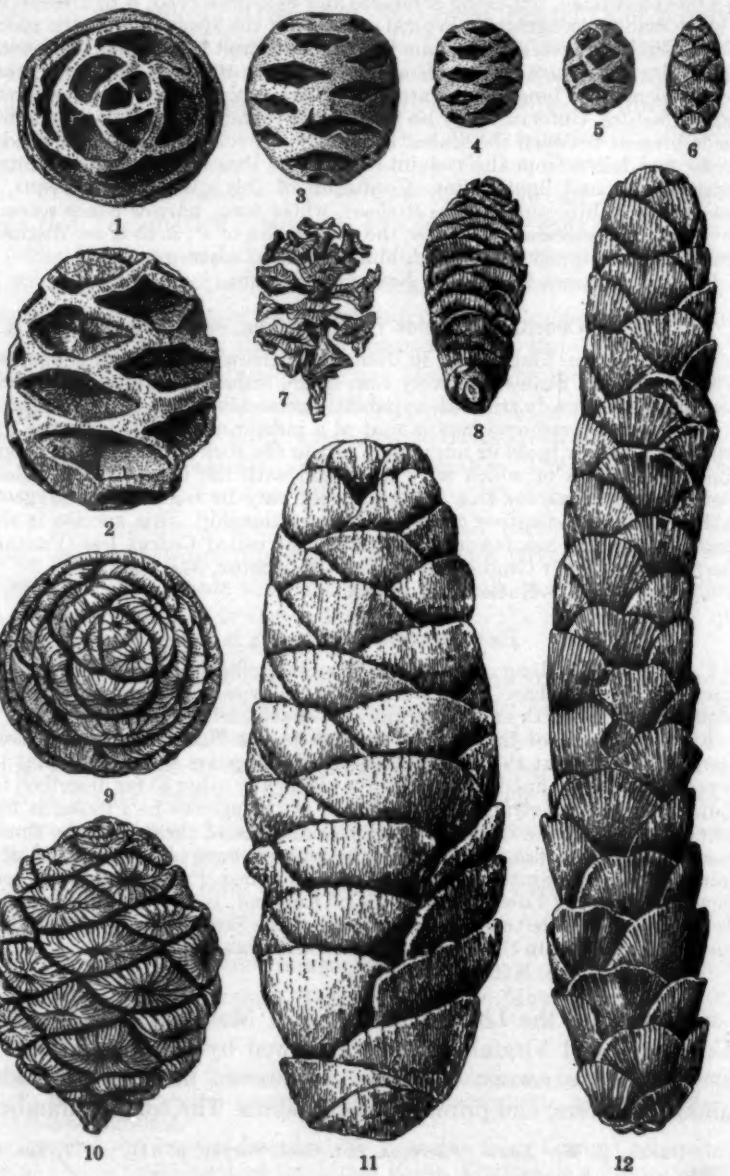
Type in the U.S. National Museum.

The flora of the Lower Cretaceous of Maryland, the District of Columbia, and Virginia, is fully reviewed by Berry[6] who lists 144 species. These consist of ferns, clubmosses, horsetails, cycads, a ginkgo, conifers, and primitive angiosperms. The conifers number 29

[4] BERRY, E. W. *Lower Cretaceous*. Md. Geol. Survey, p. 411, pl. 77, figs. 4, 4a. 1911.

[5] SEWARD, A. C. *Fossil plants* 4: 373, text figs. 772, 773. 1919.

[6] BERRY, E. W. *Lower Cretaceous*. Md. Geol. Survey. 1911.



For explanation of Figs. 1–12, see bottom of opposite page.

species and are distributed among the genera *Nageiopsis, Cephalotaxopsis, Brachyphyllum, Araucarites, Abietites, Pinus, Cupressinoxylon, Frenelopsis, Sphenolepis, Laricopsis, Arthrotaxopsis, Widdringtonites, Cedrus,* and *Sequoia.* It is almost needless to say that, although most of these genera may be recognized readily, little is actually known about their exact botanic relationships. The disposition of the three cones discussed above must be regarded as tentative until cones and foliage are found in organic connection when a realignment may be necessary.

NORTH DAKOTA FOSSIL CONIFERS

A short distance beyond the bridge over the Cannonball River thirty miles south of Mandan, North Dakota, another highway branches off eastward toward Solen and the mouth of the Cannonball on the Missouri River. In secs. 31 and 32, T. 134 N., R. 81 W., on both sides of that highway, badlands appear in the somber-colored strata of the lower part of the Lance formation, immediately above the Fox Hills sandstone and beneath the Cannonball marine member of the Lance. The weathering of ferruginous lenses in these somber beds isolates the well-preserved mud casts of *Sequoia* cones (Figs. 1, 2). A similar occurrence in the same beds is located along the Cannonball River in sec. 36, T. 131 N., R. 86 W., where the cones are normally somewhat smaller in size. At both localities the writer and Kiguma J. Murata, of the United States Geological Survey, in 1931, found detached, fragmentary leaves and twigs of *Sequoia.*

Sequoia dakotensis Brown, n. sp. Figs. 1–4

Cones, 1.5–4 cm. long, 1.2–3 cm. in diameter, with about 30 scales, arranged in two sets of spiral rows, the steep-angled set in 5 rows, and the flat-angled set in 3 rows. The faces of the scales present sections that are long and narrow, roughly diamond-shaped, but occasionally with one or two additional angles. Peduncle of the scales abruptly narrowed to the point of attachment at the axis of the cone. Surface of the scales smooth, or sometimes slightly wrinkled.

These cones are ferruginous mud casts, the solid portion of which represents the spaces, and the cavities the woody substance of original cones like those of the redwood (*Sequoia sempervirens*), Figure 7, or the big tree (*S.*

Figs. 1–4.—*Sequoia dakotensis* from the Eocene (?) of N. Dak. Fig. 1 is a top view of Fig. 2. Fig. 5.—*Sequoia ambigua* from the Lower Cretaceous, Muirkirk, Md. Fig. 6.—*Tsuga canadensis* from alluvial deposits on Northwest Branch of Anacostia River, Md. Fig. 7.—*Sequoia sempervirens,* living redwood, Calif. Fig. 8.—*Piceites cretaceus* from the Lower Cretaceous on Northwest Branch, Md. Figs. 9, 10.—*Sequoia gigantea,* living big tree, Calif. Fig. 11.—*Cedrites primevus* from the Lower Cretaceous on Northwest Branch, Md. Fig. 12.—*Abietites macrocarpus* from the Lower Cretaceous on Northwest Branch, Md. All figures natural size. Drawings by Miss Frances Wieser.

gigantea), Figures 9 and 10. Falling from a tree into water, the original cones became water-logged, sank to the bottom and were covered with mud that also filled the spaces between the scales. The dissolution of the wood helped to impregnate and harden the mud with iron oxide; but the spaces occupied by the slowly disintegrating woody scales did not have an opportunity to be filled with soft mud because the mud surrounding the cone had also hardened in the meantime; hence, in the resulting fossil casts the original woody parts are represented by cavities.

Some 50 species of *Sequoia* have been described from American strata ranging in age from Lower Cretaceous to Pleistocene. Many of these are designated merely as *Sequoia* sp., the rest by binomials. In few instances have cones and foliage been found in organic connection, so that it is most likely that more species have been described than the remains justify, although it is not improbable that 50 or more species or varieties of *Sequoia* may have been in existence during the long and widespread history of that genus. In describing the present cones as a new species the writer hopes that he is not adding to the confusion associated with the identification of fossil sequoias, many of which are based upon foliage which is known to be extremely variable and therefore not reliably diagnostic. A few species are based upon fossil wood.

Comparison of these cones with other well-preserved fossil *Sequoia* cones and with those of the living species, reveals significant differences. The scales of these cones number about 30 and are conspicuously longer than broad when viewed in face section. The normal number of scales in *S. sempervirens* varies from 14 to 26, in *S. gigantea* from 35 to 40. The fossil cones therefore belong to neither of the two living species. The fossil species, regarded as the most nearly equivalent to if not identical with the living redwood, is the Tertiary species, *S. langsdorfii*, but, having normally a less number of scales than the cones under discussion, it must be considered a different species, although Knowlton gives it a range that extends into the area and the horizon from which these cones were recovered, an extension of range and identification that apparently does not seem to be justified by the evidence. Another fossil cone given the same backward range as *S. langsdorfii* is *S. nordenskiöldi*. Since the cone type of this species described by Heer[7] is a longitudinal section only, and since there was no other basis, except figured foliage, for identifying the American material with Heer's Spitzbergen specimens there seems to be ground for questioning and perhaps rejecting this identification also. The cones of both these species taken from Cretaceous

[7] HEER, OSWALD. *Flora fossilis arctica* 2(abt. 2): 36, pl. 4, fig. 4a. 1870.

strata in North Dakota, although not identifiable with the types of those species, are, however, the same as the cones now called *S. dakotensis*.

An unattached cone similar in size and scale arrangement to *S. dakotensis* is that described by Knowlton as *Sequoia* sp.?[8] from Upper Cretaceous beds 10 miles northwest of Wild Horse Lake, Alberta, Canada. Found in the same Judith River strata on Willow Creek, 12 miles north of Musselshell post office, Montana, is much material, but no cones, of a *Sequoia* that Knowlton confidently referred to that ubiquitous Cretaceous species, *S. reichenbachi*. He intimated that the cone suggests some of the latter species figured by Heer from Greenland.[9] However, Heer's Figure 4 shows the face of the cone scales to be more broadly rhomboidal than those of Knowlton's cone. Similarly, Berry's cone[10] of this species, although smaller than Heer's, has the same broadly rhomboidal scale faces, agrees with Heer's type, but differs from Knowlton's. It appears therefore that the North Dakota and Alberta cones cannot be referred with assurance to *S. reichenbachi*. For the same reason, namely, the more broadly rhomboidal shape of the scale faces, that small-coned species, *S. ambigua* (Fig. 5), originally described by Heer from Greenland and reported by Fontaine[11] from Lower Cretaceous beds at Dutch Gap Canal, Virginia, and Muirkirk, Maryland, is a species different from *S. dakotensis*. Cones, similarly preserved and indistinguishable from *S. dakotensis*, were collected in 1907 by Barnum Brown from the Hell Creek member of the Lance formation in the valley of Big Dry Creek, 28 miles south of Lismas and 35 miles northwest of Circle, Montana, and were identified as *S. heeri* by Arthur Hollick. This, however, is clearly a misidentification, for Lesquereux's type of *S. heeri*[12] from Sage Creek, near Medicine Lodge, Montana, is a small, crumpled cone having less than 20 scales, and is, in fact, an example of *S. langsdorfii*, similar to the smaller cones of that species from the lower part (Bridge Creek shale of authors) of the John Day formation in Oregon, and also mistakenly identified as *S. heeri* by J. S. Newberry and F. H. Knowlton.

[8] STANTON, T. W., and HATCHER, J. B. *Geology and paleontology of the Judith River beds, with a chapter on the fossil plants* by F. H. Knowlton. U.S. Geol. Survey, Bull. **257**: 131, pl. 14, fig. 2. 1905.

[9] HEER, OSWALD. *Flora fossilis arctica* 3(abt. 2): 77, pl. 20, figs. 1–8. 1875.

[10] BERRY, E. W. *The upper Cretaceous and Eocene floras of South Carolina and Georgia*. U.S. Geol. Survey, Prof. Paper **84**: 23, pl. 4, fig. 1. 1914.

[11] FONTAINE, W. F. *The Potomac or younger Mesozoic flora*. U.S. Geol. Survey, Mon. **15**: 245, pl. 120, fig. 6. 1889.—Ibid., Mon. **48**: 555, pl. 110, fig. 13. 1905.

[12] LESQUEREUX, LEO. *The Tertiary flora*. U.S. Geol. Survey Terr. Rept. **7**: 77, pl. 7, fig. 13. 1878.

The strata in which the cones of *S. dakotensis* were found belong to a group whose geologic age is in dispute, the United States Geological Survey designation being Eocene (?). Some students assign the beds to the Upper Cretaceous, others regard them as early Eocene. Similarly the age of the somewhat younger Fort Union formation has also been questioned. In the latter, at several localities in North Dakota, Montana, and Wyoming, the writer has found *Sequoia* cones that greatly resemble *S. dakotensis*, except that apparently the average number of scales is about 28, a reduction from *S. dakotensis* and an approach toward the *S. langsdorfii* and *S. sempervirens* types. Whether these considerations concerning *S. dakotensis* can be made a part of the basis for the geologic dating of these disputed beds remains to be tested by further evidence.

Types and figured specimens in the U. S. National Museum.

ORNITHOLOGY.—*A new race of the crested eagle-hawk*, Spizaetus ornatus.[1] HERBERT FRIEDMANN, U. S. National Museum.

On examining a long series of *Spizaetus ornatus*, representing the combined material of the Museum of Comparative Zoölogy, the Academy of Natural Sciences of Philadelphia, the Carnegie Museum, the Field Museum, California Institute of Technology, United States Biological Survey, and the United States National Museum, it became evident that there were two races involved, one from the Guianas, Brazil, and Venezuela, to Paraguay, northeastern Argentina, and Bolivia; and one from Mexico and Central America, south to Colombia and Ecuador, and, possibly, to Peru. When sending me the Carnegie Museum series, Mr. Todd wrote me that he had long suspected the existence of two races, a Central American and a South American. When I found that there were indeed two races although their ranges were not quite as Todd's brief note suggested, I wrote him suggesting that he describe the northern form. This he declined to do as I had all the material assembled before me. The least I can do in return for his courtesy is to use one of his specimens as the type of the new race.

Inasmuch as the type locality of *ornatus* is Cayenne, it follows that this name must be applied to the birds of the Guianas, Brazil, etc. Although several synonyms are extant for the nominate race, no name seems to be applicable to the Central American-western South American form. I therefore propose the name

[1] Published by permission of the Secretary of the Smithsonian Institution. Received June 29, 1935.

Spizaetus ornatus vicarius subsp. nov.

Type: Carnegie Museum number 24881, adult female, collected by Morton E. Peck, in the pine ridge country near Manatol Lagoon, British Honduras, July 5, 1905.

Subspecific characters: Adult similar to that of the nominate race, but with the sides of the face, neck, and throat duller, snuff brown to mikado brown (instead of cinnamon rufous to hazel as in typical *ornatus*); the abdomen more heavily streaked with black transverse spots; and with the black malar stripe from the angle of the bill, separating the brown cheeks and auriculars from the white chin and mid-throat, generally, but not invariably, broader: young similar to that of the nominate race, but with the crown generally more heavily washed with tawny cinnamon and with numerous, small, dark fuscous streaks (crown almost or entirely without dark fuscous streaks in young of the typical form).

Range: As indicated above—southern Mexico, Guatemala, Honduras, British Honduras, Nicaragua, Costa Rica, Panama, Colombia, and Ecuador. I have seen no Peruvian specimens and cannot say whether or not birds from that country are of this form. The species has been recorded from Chyavetas, Peru. I should expect from the fact that the Ecuadorian bird seen (from Paramba in northern Ecuador) is *vicarius* and that Bolivian examples seen (from Rio Surutu and Rio Yapacani) are *ornatus*, northern Peruvian birds would be closer to *vicarius* and southern and especially southwestern ones to *ornatus*.

I have seen no birds from Trinidad and assume that they are *ornatus* like those from Venezuela. However, the only Tobago bird seen, a young one, is as similar to *vicarius* as to *ornatus*. It may be, however, that the juvenal plumage characters of the two races are not valid, in which case there would be no reason for considering this bird *vicarius*.

Material examined: S. o. ornatus: 8 specimens from British Guiana, Brazil, Venezuela, Paraguay, Bolivia, and one from Tobago that may be *vicarius*.

S. o. vicarius: 25 specimens from Mexico, Guatemala, Honduras, British Honduras, Nicaragua, Costa Rica, Panama, Colombia, and Ecuador.

I am greatly indebted to Mr. Peters, Dr. Stone, Mr. Todd, Mr. Boulton, Mr. van Rossem, and Mr. Wheeler for the loan of material used in this study.

ZOOLOGY.—*Chinese spiders of the family* Lycosidae.[1] IRVING FOX. (Communicated by PAUL BARTSCH.)

Through the kindness of the United States National Museum I was granted the opportunity of studying a collection of spiders made by D. C. Graham in Szechwan Province, China, during the years 1923 to 1930. I wish to express my appreciation to the authorities of the Museum for their helpfulness while this study was in progress, and especially to E. A. Chapin, curator of the Division of Insects. All the species described or discussed in this paper are in the collection of the United States National Museum.

[1] Received June 27, 1935.

Arctosa gertschi, n. sp.

Male: Total length, 10.8 mm. Carapace, 6.23 mm. long, 4.05 mm. wide. Carapace dark brown in the alcoholic specimen, with indications of a lighter median band. Sides brown, with marginal lines of white hairs. Sternum, labium, endites, and coxae black. Legs reddish brown without annulations. The shrivelled abdomen is black.

First row of eyes narrower than the second (33/37), slightly procurved, the medians larger, closer to each other than to the laterals. Eyes of the second row their diameter apart. Third row wider than the second (45/37), and much narrower than the carapace at that point. Quadrangle of posterior eyes wider than long (45/34). Clypeus equal in height to five-sixths the diameter of the anterior median eyes. Chelicerae with two teeth on the lower margin, and three on the upper. Legs stout, the tibiae with 2-2-2-spines below, the last pair apical, the posterior tibiae with basal and submedian spines above. Tibia and patella I, 6.23 mm. long. Tibia and patella IV, 7.02 mm. long. Male palpal organ as figured.

TYPE LOCALITY.—China: male holotype from Chaotung, Yunnan Province, 1925. Type: U. S. N. M. Cat. No. 1137.

Although this spider differs markedly from the generality of the species of *Arctosa* in the spinal armature of the anterior and posterior tibiae, the structure of the palpal organ is characteristic of that genus resembling in certain respects that of the male palpus of *Arctosa cinerea* (Fab.), the genotype.

Lycosa wulsini, n. sp.

Female: Total length, 17.50 mm. Carapace, 9.30 mm. long, 7.13 mm. wide. Abdomen, 8.22 mm. long, 6.14 mm. wide. Carapace brown, with a median longitudinal light band which is wider than the posterior row of eyes anteriorly, but which narrows abruptly before the dorsal groove, and continues backward as a line about one-third the width of the anterior portion. Sides of the carapace dark brown with distinct broad, whitish, submarginal lateral stripes limited by narrower brown bands below them. Marginal lines of white hairs at the edges of the sides. Sternum, labium and endites black. Legs brown shaded with black; coxae black with lighter portions at the bases, femora with indistinct longitudinal black lines above. Abdomen brown above; at the base a solid black mark extending a little more than half the length of the abdomen. At the posterior portion of this mark, and below it are scattered numerous black dots. Venter of the abdomen with a solid black spot which would include the entire venter were it not outlined on all sides by an orange band.

First row of eyes narrower than the second row (40/43), slightly procurved, median eyes larger than the lateral, and closer to the lateral than to each other. Eyes of the second row further apart than the diameter of one of them (17/13). Posterior row of eyes broader than the second row (57/43), much narrower than the width of the carapace at that point. Quadrangle of posterior eyes broader than long (57/45). Clypeus higher than the diameter of the anterior median eyes (9/7). Chelicerae armed with three teeth on the lower margin. Legs moderately stout, tibiae with 2-2-2 spines below, the last pair apical, the posterior tibiae with basal and submedian spines above. Tibia and patella I, 5.15 mm. long. Tibia and patella IV, 8.71 mm. long. Epigynum as figured.

TYPE LOCALITY.—China: female holotype from Shanghai, collected by the National Geographic Society Expedition under F. R. Wulsin, August, 1922. Type: U. S. N. M. Cat. No. 1138.

Lycosa chapini, n. sp.

Female: Total length, 14.35 mm. Carapace, 7.12 mm. long, 5.74 mm. wide. Abdomen, 7.22 mm. long, 5.05 mm. wide. Carapace brown, anteriorly with a light reddish brown design consisting of a thin median line extending from the posterior lateral eyes to the dorsal groove, and a short but wide transverse bar crossing this, giving off at its ends two thin lines which meet forming a point with the median line. Sides of the carapace brown with submarginal light bands having irregular edges and frequent interruptions. Clypeus reddish brown with dark discolorations below the lateral eyes. Chelicerae densely covered with long hairs. Sternum, labium, and endites brown with lighter edges. Sternum with a lighter central area. Dorsum of the abdomen reminiscent of *Pardosa* having a black mottled ground on which are four pairs of indistinct light spots with black centers. Venter pale or reddish. Legs brown, femora with four rings, rest of the joints indistinctly annulate.

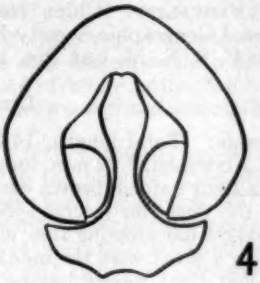
First row of eyes narrower than the second (31/37), slightly procurved, medians larger, somewhat closer to the laterals than to each other. Eyes of the second row their diameter apart. Third row of eyes wider than the second (55/36). Clypeus high, about one and one-half the diameter of the anterior median eyes. Chelicerae armed with three teeth on the lower margins. Legs tapering from the proximal to the distal ends, tibiae with 2-2-2 spines below, the last pair apical. Tibia and patella I, 8.12 mm. long. Tibia and patella IV, 9.21 mm. long. Epigynum as figured.

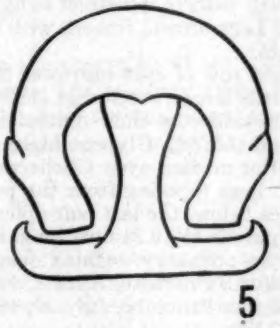
TYPE LOCALITY.—China: female holotype from Kunghsien south of Suifu, Szechwan Province, April 3, 1930; three female paratypes from Tatsientu, Szechwan Province, July 20, 1923. Type and paratypes: U. S. N. M. Cat. No. 1139.

Lycosa chengta, n. sp.

Female: Total length 11.00 mm. Carapace, 4.55 mm. long, 3.66 mm. wide. Abdomen, 6.43 mm. long, 2.57 mm. wide. Carapace brown, medially with a light central orange band as wide as the third row of eyes. A short tongue-like projection from this band goes forward between the eyes of the third row to a point midway between this row and the second eye row. At the dorsal groove the band has irregular edges; posteriorly it tapers to a narrow stripe. Sides of the carapace brown, the margins black with wide submarginal light bands. Sternum and labium dark brown, endites and coxae lighter. Legs light brown; femora with annulations. Dorsum of the abdomen brown, medially with several pairs of light brown spots with black centers arranged in series. Venter the same color as the dorsum.

First row of eyes narrower than the second (21/29), straight, the medians larger and closer to the laterals than to each other. Eyes of the second row their diameter apart. Third row of eyes wider than the second (36/29), and much narrower than the carapace at that point. Quadrangle of posterior eyes broader than long (36/26). Clypeus one and one-half times as high as the diameter of the anterior median eyes. Chelicerae with three teeth on the lower margin. Legs slender, the tibiae armed with 2-2-2 spines below, the last pair apical, the posterior tibiae with basal and submedian spines above.





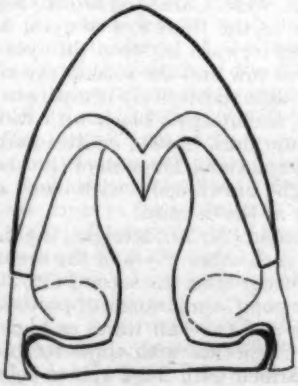


Fig. 1.—*Lycosa subcoelestis*, n. sp., carapace. Fig. 2.—*Arctosa gertschi*, n. sp., male palpus, ventral view. Fig. 3.—*Lycosa grahami*, n. sp., epigynum. Fig. 4.—*Lycosa wulsini*, n. sp., epigynum. Fig. 5.—*Lycosa chengta*, n. sp., epigynum. Fig. 6.—*Lycosa chapini*, n. sp., epigynum.

Tibia and patella I, 5.24 mm. long. Tibia and patella IV, 6.03 mm. long. Epigynum as figured.

TYPE LOCALITY.—China: female holotype and three female paratypes from Chengtu, Szechwan Province, 1200 feet, April 1, 1930. Type: U. S. N. M. Cat. No. 1140.

Lycosa coelestis L. Koch

Lycosa coelestis L. Koch Verh. Zool-Bot. Gesell. Wien 27: 772, pl. XVI, figs. 35, 36. 1877.

RECORDS.—China: Szechwan Province, Suifu, 1000 feet, May, 1924, 3 females and 2 males; June, 1925, one female; May, 1930, one female.

Lycosa grahami, n. sp.

Female: Total length, 14.35 mm. Carapace 7.62 mm. long, 5.94 mm. wide. Carapace reddish brown in the alcoholic specimen, showing signs of a lighter median longitudinal band. Sides of the carapace edged with black. Sternum, labium, endites, and coxae blackish brown. Legs reddish brown with longitudinal black stripes at the lateral faces. Abdomen (shrivelled in the specimen) black.

First row of eyes narrower than the second (30/34), slightly procurved, the eyes subequal with the medians closer to the laterals than to each other. Second row narrower than the third (34/49), the eyes more than their diameter apart. Quadrangle of posterior eyes wider than long (49/36). Clypeus much higher than the diameter of the anterior median eyes (9/5). Chelicerae with three teeth on the lower margins. Legs moderately stout, tibiae with 2-2-2 spines below, the last pair apical. Tibia and patella I, 7.33 mm. long. Tibia and patella IV, 7.92 mm. long. Epigynum as figured.

TYPE LOCALITY.—China: female holotype from Chaotung, Yunnan Province, 1925. Type: U. S. N. M. Cat. No. 1141.

Lycosa pseudoannulata (Bosenberg and Strand)

Tarentula pseudoannulata Bosenberg and Strand Abh. Senckenb. Naturf. Gesell. 30: 319, pl. 8, fig. 106; pl. 13, figs. 323, 326, 334, 338. 1906.

RECORDS.—China; Szechwan Province, Suifu, 1000 feet, many females, males, and immatures taken November 25, 1929, October 15, 1930, and June, 1930; Kuanshien, 2000 feet, March 2, 1930, females; Kunghsien, 1200 feet, April 3, 1930, males and females; Chengtu, 1200 feet, April 1, 1930, females; Yunnan Border, 6000 feet, October, 1928 males, females, and immatures.

Lycosa subcoelestis, n. sp.

Female: Total length 10.89 mm. Carapace 5.64 mm. long, 4.45 mm. wide. Abdomen 5.05 mm. long, 4.15 mm. wide. Carapace brown with a median longitudinal light brown band which begins at a point midway between the second row of eyes and the third row. This band widens as it progresses backwards, half-way down the cephalothorax it is as wide as the third eye row, here it abruptly narrows to a thin line one-third the width of the anterior portion which widens slightly at the dorsal groove, but narrows again after leaving it. Sides of the carapace brown, the margins dark, with submarginal light bands. Sternum and endites light brown, the labium darker, coxae and the other joints of the legs clear light brown. Abdomen orange at the sides, medially with a narrow light brown, basal band extending almost one-half the total length of the abdomen; at its caudal end this

band bears two light spots on each side. Posterior portion of the abdomen with numerous yellow spots scattered in the dark field. Venter orange.

First row of eyes as wide as the second, straight, the medians larger, and closer to the laterals than to each other. Eyes of the second row their diameter apart. Third row of eyes broader than the second (35/26), and much narrower than the carapace at that point. Quadrangle of posterior eyes wider than long (35/28). Clypeus equal in height to the diameter of the anterior median eyes. Chelicerae with three teeth on the lower margin and strong indication of a fourth one. Legs moderately stout, the tibiae with 2-2-2 spines below, the posterior tibiae with basal and submedian spines above. Tibia and patella I, 4.55 mm. long. Tibia and patella IV, 5.14 mm. long. Epigynum: Similar to that of *Lycosa coelestis* L. Koch.

TYPE LOCALITY.—China; female holotype from Suifu, Szechwan Province; 3 female paratypes from Yachow District, Szechwan Province, 1800 feet, May 1928; 2 female paratypes from the Yunnan Border, 6000 feet; 2 female paratypes from Shin Kai Sei, Mt. Omei, 4400 feet. Type: U. S. N. M. Cat. No. 1142.

This species closely resembles *Lycosa coelestis* L. Koch, but is distinguishable from it by the different designs on the cephalothorax and abdomen (fig. 1), by the light sternum and venter, and by the smaller size. Paratypes from the above localities were smaller than the type by as many as 3 mm. The total length of the females of *L. subcoelestis* varies from 8.5 to 11.5 mm., while that of *L. coelestis* L. Koch ranges from 12 to 15 mm.

Pardosa astrigera L. Koch

Pardosa astrigera L. Koch Verh. Zool-Bot. Gesell. Wien 27: 775, pl. 16, figs. 37, 38. 1877.

RECORDS.—China: Szechwan Province, Suifu, 1000 feet, May 1928, 3 females; Yachow District, 1800 feet, May, 1928, female.

Pardosa laura Karsch

Pardosa laura Karsch Verh. Ver. Rheinl. 36: 102, pl. 1, fig. 21. 1879.

RECORDS.—China: Szechwan Province, Suifu, 1000 feet, June 1925, female; May, 1928, 3 females; Shin Kai Sei, Mt. Omei, 4000 feet, August 7, 1929, female; Yachow District, 1800 feet, May, 1928, female; West of Yachow, 2000 feet, June, 1923, male.

Mature females have distinct annulations on the legs, which is in accordance with Karsch's original description. The annulations of the legs of males, however, are indistinct and sometimes obsolete.

Pirata clercki (Bosenberg and Strand)

Tarentula (*Piratica*) *clercki* Bosenberg and Strand Abh. Senckenb. Naturf. Gesell. 30: 316, pl. 8, fig. 107; pl. 13, fig. 320. 1906.

RECORDS.—China: Szechwan Province, Suifu, 1200 feet, April 1, 1930, 2 females; Kunghsien, 1200 feet, April 3, 1930, five females; Chungking, 6000 feet, September 20, 1930, 2 females.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1077TH MEETING

The 1077th meeting was held in the Cosmos Club Auditorium, January 5, 1935, President GISH presiding.

An address entitled *The frontiers of aerodynamics*, illustrated by slides, was delivered by the retiring President H. L. DRYDEN. This address was published in this JOURNAL **25**: 101–122, 1935.

1078TH MEETING

The 1078th meeting was held in the Cosmos Club Auditorium, Saturday, January 19, 1935, President GISH presiding.

Program: PAUL SMITH: *Ray paths of sound in deep sea water.*—During 1933 and 1934, experiments were made by the U. S. Coast and Geodetic Survey to determine the horizontal path of sound through sea water, and valuable information has been obtained. The ships *Pioneer* and *Guide* on the Pacific Coast operated in depths of about 1000 fathoms and many oscillograph and chronograph records were made of small bombs fired near the surface and to depths of 600 fathoms, with distances from 16 to 48 kilometers between ships. On the Atlantic Coast, the ships *Oceanographer* and *Lydonia* experimented with both ships in depths of 1450 fathoms and again with one ship stationed at 793 fathoms while the other steamed toward shore into shoal water. In the Atlantic Coast experiments, time intervals were measured only by chronograph. The records of these experiments show that up to certain distances the bomb signal may be received by difracted paths and also by reflected paths between the bomb and the hydrophone. The experiments have given data of great value for the purpose of increasing the accuracy of radio acoustic ranging. (*Author's abstract.*)

HERBERT G. DORSEY: *The Dorsey fathometer.*—To be published in this JOURNAL.

These papers were discussed by Messrs. GISH, STIMSON, HUMPHREYS, CURTIS, MCNISH and RUDE.

1079TH MEETING

The 1079th meeting was held in the Cosmos Club Auditorium, February 2, 1935, President GISH presiding.

Program: L. S. TAYLOR: *The problem of measurement of x-rays and gamma-rays.*

F. L. MOHLER: *Bactericidal effects of x-rays.*—When an X-ray quantum is absorbed by matter the entire energy is given to a single electron. This high-speed electron gradually dissipates its energy leaving a trail (column) of ions behind it. In liquids and solids the density of ionization in these columns is so great that nearly all the ions recombine and the effects are strictly limited to the columns of ionization. The theory proposed is that killing bacteria depends simply on the chance that a column of ionization passes through the cell or a certain part of the cell and the probability is expressed in terms of the effective collision area S for a fatal encounter. If this is true then the fraction surviving an exposure of time t will be $A(t)/A_0$

$=e^{-at}$. Wyckoff and Rivers[1] studied first the killing of bacteria by 155 kv cathode rays. A dilute culture of colon bacilli was flowed over a surface of agar jelly and exposed to a measured current of cathode rays. After an incubation period a count of the colonies gave the survival ratio which depended on exposure time according to the exponential law. If S is the area sterilized by each cathode ray then nS is the fraction of the area sterilized by a flux of n cathode rays per second and nS can be equated to a. The resulting value of S is $.76\times10^{-10}$ cm.[2] The bacilli are short rods with cross sections of the order of 10^8 cm^2 so the vital spot is a small part of the bacillus.

Wyckoff has published comparable measurements of the killing of colon bacilli by characteristic soft X-rays of different wave lengths. In this case the dosage in r units is given. From this one can estimate the number of quanta n absorbed per cm^3 per sec. in the agar. Each fast electron goes a distance x and sterilizes a volume Sx. Equating nSx to a gives values of S which vary somewhat with the X-ray wave length. Wave lengths of .56 and .70A give values nearly the same as for cathode rays, viz. $.7\times10^{-10}$ cm^2. Wave lengths ranging from 1.5 to 4A give values from 1.9 to 2.6×10^{-10} cm^2. The density of ionization is very much greater for the longest wave lengths so that the effectiveness in terms of r units is much less for the longest wave lengths.[2] (*Author's abstract.*)

F. O. Coe: *Opaque media in clinical roentgenography.*—After the first few months of the use of Roentgen rays in medicine one of the early writers concluded that Roentgenographic methods would be of some value in the following conditions: (1) foreign bodies imbedded in any of the soft tissues of the body; (2) foreign bodies in certain of the organs and viscera; (3) foreign bodies found within the body itself. (4) inflammatory swellings and new growths; (5) fractures and dislocations.

In Roentgen's first two classical communications he reported his findings on the absorption of X-rays by a large number of metals and other substances. Roentgen had noted that lead, gold and heavier metals were opaque to the rays he was using, while some of the lighter metals and some organic substances were much less so.

Dr. Williams of Boston suggested the use of bismuth subnitrate mixed with food in the fluoroscopic examination of the esophagus, and thus was created the prototype of all subsequent diagnostic procedures in the esophagus.

Immediately following the first experiments bismuth subnitrate meals were used in the examination of the stomach. Cannon then gave dogs and cats bismuth with their meals and did his classical research on the gastrointestinal tract. About 1917 barium sulphate was substituted and has since been in use. This media complies with all of the necessary requirements. It is of high atomic weight, is easily obtained in a pure form, is non-toxic and is inexpensive.

Because of their high atomic weight and lack of toxicity in certain chemical combinations the substances now being commonly used are barium sulphate; iodine in many combinations; and thorium in several forms.

The law governing the absorption of Roentgen rays in general is that the absorption is directly proportioned to the fourth power of the atomic number.

These opaque substances used in clinical Roentgen diagnosis have been administered in two ways: (1) By direct introduction into the hollow viscera, either by swallowing them or by injection, (2) those given by mouth

[1] J. Exp. Med. 51: 921. 1930.
[2] J. Exp. Med. 52: 435. 1930.

or intravenously, and then selectively excreted or absorbed in certain organs.

The element of danger in the use of Roentgen rays has been recognized and largely overcome. The present problem is the refinement and extension of available methods and of more importance, the correct interpretations of the many variations from the normal pattern. (*Author's abstract.*)

These papers were discussed by Messrs. TUCKERMAN, WENNER, GISH, HUMPHREYS, MAXWELL, CURTIS and KRACEK.

1080TH MEETING

The 1080th meeting was held in the Cosmos Club Auditorium, February 16, 1935, President GISH presiding.

Program: F. B. SILSBEE: *Superconductivity at radio frequencies.*—The results of measurements made in the temperature range 2.5°K to 4.2°K on the electrical resistance of wires of tin and of tantalum were reported. These showed that the temperatures at which half of the resistance had vanished were the same for alternating currents of frequencies up to 10^6 cycles per second as for direct current. The effective resistance when the specimens were well below their transition temperatures were too small to detect even at radio frequencies by the calorimetric and electrical methods tried.

Experiments in which alternating current of 200 kilocycles per second was superposed on direct current in a tin wire showed a component of potential difference having a frequency of 400 kilocycles per second. The magnitude of this component, and its variation with temperature and with the values of the currents, indicated that the specimen must have been fluctuating in resistance cyclically as a result of the cyclic disturbance of the superconducting condition by the magnetic field of the currents. (*Author's abstract.*)

F. G. BRICKWEDDE: *The uses of deuterium and the measurement of its vapor pressures.*—Published in this JOURNAL 25: 157–166, 1935.

These papers were discussed by Messrs. IVES, GISH, KRACEK, MCNISH, TUCKERMAN, ROESER, SWINGLE and others.

Informal communication.—H. L. DRYDEN presented the Society with a gavel made from historic wood, by M. LANGE of the National Bureau of Standards, and inscribed as follows: "This gavel was made from timbers placed in the White House in 1816 and removed in 1927."

1081ST MEETING

The 1081st meeting was held in the Cosmos Club Auditorium, March 2, 1935, President GISH presiding.

Program: L. V. BERKNER: *Ionosphere observations at the department of terrestrial magnetism of the Carnegie Institution of Washington.*—Exploration of the ionization of the earth's upper atmosphere or *ionosphere* are made possible by the transmission of radio waves and observation of the reflections returned. Methods have been devised which allow the recording of the state of this ionization through the whole height of the region. Observations by these methods have been made in both the northern and southern hemispheres and give generalized ideas concerning the ionosphere.

Two general regions of ionization are found at night. The lowest or *E*-region ionization exists at about 100 km. The highest or *F*-region ionization is observed above 250 km. With sunrise, the ionization of both regions increases rapidly. If the latitude is such that the sun approaches within about 40° of the zenith at noon, the *F*-region separates into two ionized regions.

The lower of these, the F_1-region falls to about 180 km. while the upper or F_2-region rises to above 300 km. As a result, the F_2-region appears as a bulge roughly circular in area under the sun, with the F_1-region beneath it and depressed below the level of the surrounding F_2-region, with the two layers merging together at zenith angles of about 40°.

The maximum ionization of the E- and F_1-regions varies with the altitude of the sun, and this consideration together with the data obtained during the solar eclipses shows that the chief ionizing agency must be ultra-violet light. The maximum ionization of the F_2-region starts to rise with sunrise, but if the sun reaches high altitudes, the rise ceases or a decrease occurs near noon, with a rise to a maximum in the afternoon or evening. A great variability in maximum ionization of the F_2-region ionization occurs from day to day. These interesting and complex effects cannot be explained as a simple function of the altitude of the sun, as is the case with the lower layers. It is significant that such variability should occur in the region of the atmosphere most directly exposed to the sun, above which the absorption of the sun's rays is small.

Sources of ionization other than ultra-violet light are known to be present in the lower region between 100 and 150 km. This is evidenced by sudden increases in ionization to abnormal values which may occur at any time during the twenty-four hours. Such ionizations have been shown to be local rather than general in extent.

There is also some evidence that intermediate regions of ionization may exist between the E- and F-regions, but it is difficult to determine whether such regions actually exist separately, or whether the effects may be due to an inhomogeneity of ionization of the whole region of ionization which must extend upward from the E-region to the F-region. The evidence for very high night layers is also considered, but the data is not sufficiently complete to reach any conclusion, as such effects might arise from other causes. (*Author's abstract.*)

E. O. HULBURT: *Theory of the ionosphere.* The atmosphere above about 180 km. is heated by the absorption by molecular oxygen of the spectral region from 1200 to 1800A of sunlight. Calculation indicates that the temperature of the atmosphere from 180 to 300 km. may increase 50° per hour in the daytime, which causes molecular oxygen, and possibly nitrogen, to dissociate into atoms. Due to the heating and dissociation there is a marked daily expansion, and nightly contraction, of these outlying levels.

For a static atmosphere, with no motion, winds or diffusion, the density y of the ionization of any region during the day is related to the zenith angle Z of the sun approximately by

$$y = y_0\sqrt{\cos Z} \qquad (1)$$

if the recombination coefficient of electrons and positive ions is of the form given by the three body collision theory of Sir J. J. Thomson, and if the ultra-violet light of the sun is the cause of the ionization.

The recently published ionosphere data of the National Bureau of Standards and the Department of Terrestrial Magnetism of the Carnegie Institution are the most comprehensive and accurate which have yet been obtained and constitute the first approach to a world-wide survey of the ionosphere.

The E *region.*—The hourly average values of y of E agree closely, within 10 per cent, with (1) throughout the year, showing that the solar ultra-

violet light is the cause of the ionization and, as expected from theory, that diffusion is unimportant. Sporadic variations of y may be due to winds and to the liberation of energy by excited atoms and molecules.

The F_1 *region.*—The observed diurnal and seasonal curves of y of F_1 are somewhat flatter than those given by (1). Diffusion of the ionization seems adequate to account for the difference between the observed and theoretical curves.

The F_2 *region.*—For F_2 the ionization caused by solar ultra-violet light is modified by the daily expansion of the atmosphere above 200 km. and by the winds which result from the expansion. Omitting details it may be stated that the theory gives qualitative agreement with most of the complex daily and seasonal changes in F_2, such as the double daily maximum of y of F_2 at the equator, the noon winter maximum and the evening summer maximum in temperate regions. (*Author's abstract.*)

These papers were discussed by Messrs. MOHLER, HAWKESWORTH, GISH and others.

Presentation of a paper on *Ionosphere observations of the National Bureau of Standards* was cancelled due to illness of the author.

Informal communications: E. BUCKINGHAM: *The calculation of potential flow in aerodynamics.*

H. C. DICKINSON: *The statistical distribution of actual incomes as compared to the presumably random distribution of earning ability.*

1082ND MEETING

The 1082nd meeting was held in the Cosmos Club Auditorium, March 16, 1935, President GISH presiding.

Program: G. GAMOW: *The problems of beta-ray disintegrations.*—Experiments on the beta rays emitted from the radioactive elements have shown that beta particles, as ejected from the nucleus, have a continuous distribution in energy, whereas alpha particles emitted in both preceding and subsequent transformations show discrete energy values. The continuous spectrum of beta rays implies an infinity of isomers while the discrete alpha-particle energies suggest that all nuclei of the same isotope are identical.

Two hypotheses have been suggested for explaining this paradox. The first, by Bohr, escapes the beta-ray difficulty by relinquishing the Law of Conservation of Energy for interactions of beta particles at distances comparable to nuclear dimensions, since these are below the critical limit for which Dirac's theory is applicable. However, Landau has shown that Bohr's hypothesis encounters difficulties when considered from the viewpoint of general relativistic gravitation theory.

The second hypothesis, proposed by Pauli, assumes the existence of particles of zero charge, and of mass comparable to the electron, and that these particles (called *neutrinos*) are emitted at the same time as the beta particle in such a way that the sum of the energies of charged and uncharged particles is constant. The *neutrino* hypothesis appears to be most attractive at the present time, especially since it is also of value in clarifying problems in the apparently urelated field of spectroscopy. The fact that such *neutrinos* have not been observed experimentally cannot be taken as strong evidence against their existence since their properties are such as to render them practically unobservable. (*Author's abstract.*)

The lecture was discussed by Messrs. KRACEK, GISH, WHITE, TUCKERMAN, BRICKWEDDE, ROESER, GIBSON, MCNISH, SEEGER and HAFSTAD.

1083RD MEETING

The 1083rd meeting was held in the Cosmos Club Auditorium, Saturday, March 30, 1935, President GISH presiding.

The program consisted of the fifth Joseph Henry lecture by P. R. HEYL on the subject *What is electricity*. This lecture was published in this JOURNAL 25: 201–220, 1935.

1084TH MEETING

The 1084th meeting was held in the Cosmos Club Auditorium, April 13th, 1935, Vice-President HECK presiding.

Program: G. B. SCHUBAUER: *Turbulence and its relation to the diffusion of heat.*—The turbulent condition of the air in a wind tunnel is one of the factors which makes the wind in a wind tunnel unlike a natural wind and also unlike the wind created by motion through still air. Because of this fact, much attention has been given to the effect of turbulence on aerodynamic forces and to methods of measuring the amount of turbulence itself. One means of expressing the amount of turbulence in a stream is to use the root-mean-square of the speed fluctuations introduced by the turbulent motions. This quantity, usually divided by the average speed and expressed as a percentage, is often correlated with the various effects of turbulence.

Since the apparatus necessary for the measurement of percentage turbulence is quite complicated and requires considerable skill on the part of the operator, it is desirable to find some simpler measuring device which if desired might be calibrated in terms of percentage turbulence. In the search for such an instrument, a study was made of the diffusion of heat from a platinum-iridium wire, 0.002 inches in diameter and 3 inches long, placed at right angles to a stream which was made turbulent by placing ahead of the platinum-iridium wire, wire screens of various mesh size. The temperature distribution at a given distance behind the wire in the sheet of heated air carried down stream from the wire was found to be greatly affected by the amount of turbulence in the stream. The temperature distribution was determined by a thermocouple connected to a sensitive galvanometer. The width of the temperature distribution curve at half maximum temperature was selected to characterize the width of the heated sheet; and the part of this width remaining after deducting the width due to the thermal conductivity of the air was found to be a function of percentage turbulence alone, regardless of the scale or eddy size of the turbulence.[1] For this reason the width of the temperature distribution curve at half maximum temperature is a satisfactory substitute for percentage turbulence.

A study of diffusion by turbulent motions such as outlined here offers a promising field for future research both in theory and experiment. (*Author's abstract.*)

W. RAMBERG: *Propeller vibrations and propeller failures.*—The recurrence of propeller failures resulting in serious damage and sometimes in loss of life has led to numerous investigations into the causes of such failures. It was seen that failures took place at relatively low design stresses. At the same time the appearance of the fractures with their successive zones of failure supported the view that alternating stresses were the cause of failure. The generation of sufficiently intense alternating stresses could be explained only by resonance vibrations most probably sustained by periodic variations in

[1] SCHUBAUER, G. B. *A turbulence indicator utilizing the diffusion of heat.* Technical Report, No. 524, N.A.C.A., 1935.

the driving torque. The problem resolves itself into a study of the stresses set up in a propeller vibrating at a natural frequency.

The speaker reviewed briefly the work on this problem done outside the National Bureau of Standards. He then described in some detail the method of investigations used in that Bureau. He showed the electrical set-up used for exciting full-sized non-rotating propeller blades to resonant vibrations and explained the method of measuring the amplitude of these vibrations and also the stresses at the surface of the blade. A number of stress distributions obtained experimentally were shown and it was indicated that these served as an explanation of the mid-blade failures and tip failures in service.

The measured stress distributions were shown to agree satisfactorily with those computed theoretically upon the assumption that the propeller blades vibrated as a cantilever beam of variable section. A further check on the correctness of the observed results was obtained by noting that eight blades vibrated without rotation at relatively high tip amplitude, eventually developed a fatigue crack at a point where the stresses were within a few percent of the measured maximum stresses.

In conclusion the speaker pointed out some of the problems yet to be solved to explain service failures of propellers. He also demonstrated a model showing an extension of the electrical method of excitation used at the Bureau of Standards to set up vibration in a rotating propeller. (*Author's abstract.*)

The papers were discussed by MUNK, DRYDEN, TUCKERMAN, HAWKESWORTH, BRICKWEDDE, HECK, and others.

1085TH MEETING

The 1085th meeting was held in the Cosmos Club Auditorium, May 11, 1935, President GISH presiding.

Program: M. A. TUVE: *Some recent developments in high-energy physics.*—The speaker outlined the problems in this field which had been discussed at the Conference on Theoretical Physics recently held in Washington under the joint auspices of the George Washington University and the Carnegie Institution. Of the questions considered at this Conference, the following appeared to be of outstanding importance: (1) magnetic moments of the fundamental particles (2) emission of dipole or quadriipole radiation (3) interaction forces of particles (4) mechanism of capture of slow neutrons (5) energy conservation in beta-ray disintegrations (6) correction of the Aston Mass Scale (7) failure of Maxwells equations at high energies.

Discussed by Messrs. TUCKERMAN, KRACEK, ADAMS, HAFSTAD and others.

Informal communications: L. B. TUCKERMAN.—Experiments he had performed whereby material specimens placed under heavy hydrostatic pressures showed tension fractures were described. Sample test specimens were exhibited.

Discussed by TUVE, ADAMS and others.

A radio broadcast address by L. J. Briggs on the 1935 stratosphere flight was also presented as an informal communication.

L. R. HAFSTAD, *Recording Secretary*

1086TH MEETING

The 1086th meeting was held in the Cosmos Club Auditorium May 25, 1935, Vice-president WENNER presiding.

Program: PAUL H. EMMETT: *Adsorption and catalytic conversion of ortho-to para-hydrogen over iron synthetic ammonia catalysts.*—A combined study of

the adsorption of hydrogen on iron catalysts and of the influence of pressure, temperature and poisons on the catalytic ortho-para hydrogen interconversion over iron has been made. The experiments show the existence of at least three types of adsorption of hydrogen on the surface of iron synthetic ammonia catalysts, a physical or van der Waals' adsorption at −190° to 130°, a low temperature (type *A*) activated adsorption between −90° and 0°, and a higher temperature (type *B*) activated adsorption at and above 100°C. The temperature coefficient of the orthopara interconversion is positive throughout the range −190° to 60°, the latter being the highest temperature used. The apparent energy of activation became progressively larger as the temperature increased, rising from a few hundred calories at −190° to about 6000 calories at room temperature. The time for half conversion increases with the pressure both at −190° and at higher temperatures. The low temperature (−190°) conversion is presumably associated with the van der Waals' adsorption. At −78° the rate of conversion begins to increase rapidly with temperature and is apparently brought about by type *A* activated adsorption. The conversion at −190° is strongly poisoned by either the type *A* or type *B* activated adsorption, the latter being about 8 times as poisonous per unit volume adsorbed as the former. (*Author's abstract.*)

Discussed by Messrs. BUCKINGHAM, HAWKESWORTH, HUMPHREYS, TUCKERMAN, BRICKWEDDE, GIBSON and CURTIS.

Informal communication: F. G. BRICKWEDDE and R. B. SCOTT (presented by F. G. BRICKWEDDE): *The vapor pressure of hydrogen deuteride.*—Hydrogen deuteride (HD) was separated by distillation from 4 liters of an equilibrium mixture of H_2, HD and D_2, containing equal parts of hydrogen and deuterium, using a still with a reflux rectification column, immersed in liquid hydrogen. There were obtained 500 cm³ of HD of purity 99.95 percent

TABLE 1.—VAPOR PRESSURE OF HYDROGEN DEUTERIDE

Temperature, °K	Vapor Pressure in mm. of Hg		Latent Heat of HD in cal/mol	
	H_2	HD	Vaporization	Fusion
22.13[a]	1230	760.0		
20.38	760.0	438.0	261	
16.60[b]	201.4	93.6	265 (liquid)	37
16.60	201.4	93.6	302 (solid)	
13.92	54.0	15.96	296	

[a] Obtained by extrapolating the vapor pressure equation to $P(HD) = 760$ mm.
[b] Triple Point.

or better as estimated by a comparison of its vapor pressure with that of two fractions collected immediately before and after. The vapor pressure of this *pure* HD was compared with that of liquid normal H_2 in the range 13.92 to 20.38°K. The following empirical equations were obtained, expressing pressures in mm of Hg:

$$\log_{10}P(\text{HD liquid}) = -0.85411 + 1.27713 \log_{10}P(H_2) - 0.02212 \log_{10}{}^2P(H_2)$$

$$\log_{10}P(\text{HD solid}) = -1.11571 + 1.33969 \log_{10}P(H_2)$$

Using the Clapeyron equation and the equation of state of H_2 for HD, latent heats were calculated from the above equations for HD, and the vapor pressure-temperature equation of normal hydrogen.

After 15 days there was no reversion to the equilibrium mixture of H_2, HD and D_2 that could be detected by a change in vapor pressure. (*Author's abstract.*)

Discussed by Messrs. GIBSON, HAWKESWORTH, BUCKINGHAM, SEEGER, STIMSON and TUCKERMAN.

F. B. SILSBEE, *Acting Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

Washington Scientists at International Congresses.—Numerous Washington scientists served as official delegates of the United States Government at various international congresses held in Europe during the past summer and autumn. A partial list follows:

Sixth International Botanical Congress, Amsterdam, September 2 to 7: Dr. G. H. COONS, Mr. T. P. DYKSTRA, Dr. A. S. HITCHCOCK, Mr. B. Y. MORRISON and Dr. NEIL E. STEVENS, all of the U. S. Department of Agriculture, and Mr. ELLSWORTH P. KILLIP, of the U. S. National Museum.

Twelfth International Congress of Zoology, Lisbon, September 15 to 21: Dr. LEONHARD STEJNEGER, U. S. National Museum, and Dr. CHARLES W. STILES, Smithsonian Institution.

Third Conference of the International Society of Soil Science, Oxford, July 30 to August 6: Dr. C. E. KELLOGG, Dr. W. C. LOWDERMILK, Dr. A. G. MCCALL and Dr. OSWALD SCHREINER, all of the U. S. Department of Agriculture.

Sixth International Congress on Entomology, Madrid, September 6 to 12: Dr. LEONHARD STEJNEGER, U. S. National Museum, and Mr. LEE A. STRONG, U. S. Department of Agriculture.

Fourth International Technical and Chemical Congress of Agricultural Industries, Brussels, July 15 to 28: Dr. ATHERTON SEIDELL, U. S. Public Health Service, and Dr. JAMES M. DORAN, Distilled Spirits Institute.

Fourteenth Session of the Medical Days of Brussels, Brussels, June 29 to July 3: Maj. EDGAR E. HUME, Medical Corps, U. S. Army, and Medical Director C. C. PIERCE, U. S. Public Health Service.

Celebrations of Centenary of Geological Survey of Great Britain, London, July 3 to 5: Dr. ARTHUR L. DAY, Carnegie Institution of Washington.

Seventh International Congress on Industrial Accidents and Occupational Diseases, Brussels, July 22 to 26: Dr. C. C. PIERCE, U. S. Public Health Service, and Mr. WILLIAM G. RICE, Division of Labor Statistics.

First International Congress of Gastro-Enterology, Brussels, August 8 to 10: Lt. Col. JOHN H. TRIDER, Medical Corps, U. S. Army, Dr. RAY L. SEXTON and Dr. WILLIAM G. MORGAN.

Twelfth International Congress on Pharmacy, Brussells, July 30 to August 5: Maj. EDGAR E. HUME, Medical Corps, U. S. Army.

Meetings in Ibero-American Countries.—Washington scientists also attended inter-American gatherings held in the capitals of our neighbor republics to the south. Among these were:

Seventh American Scientific Congress, Mexico City, September 8 to 17: Dr. CLOYD H. MARVIN, President, George Washington University, Dr. NEIL M. JUDD, U. S. National Museum, and Dr. FRANCE V. SHOLES, Carnegie Institution of Washington.

Third Pan American Red Cross Conference, Rio de Janeiro, September 15 to 25: Rear Admiral CARY T. GRAYSON, Chairman, American National Red Cross, and Dr. THOMAS W. GOSLING, Director, American Junior Red Cross.

National Committee on Inter-American Intellectual Cooperation.—A National Committee to cooperate with the Division of Technical and Scientific Exchange of the Pan American Union was recently established and its sixteen members appointed by the Secretary of State, under the Chairmanship of Mr. JOHN W. STUDEBAKER, Commissioner of Education in the Department of the Interior. The action was taken to carry out the terms of resolutions adopted by the Seventh International Conference of American States that met in Montevideo, Uruguay, in December, 1933. Those resolutions had for their general theme the promotion of such measures as would facilitate scientific and technical interchange among the American countries in order to raise the cultural level and in general to further the advancement of the peoples of the Western Hemisphere.

Water Resources Committee.—Water resources of the United States are to be planned on a basis of national use, by a newly appointed committee which will deal with PWA projects involving any use or control of water or resources dependent on water. The scope of the committee's activities will include power, flood control, erosion, wildlife conservation, and a number of other problems. The personnel includes: ABEL WOLMAN, chairman of the Maryland Planning Board; THORNDIKE SAVILLE, of the American Society of Civil Engineers and associate dean of the College of Engineering, New-York University; N. C. GROVER, chief hydraulic engineer, water resources branch, U. S. Geological Survey; ELWOOD MEAD, director of the Bureau of Reclamation; JAY N. DARLING, chief of the Biological Survey; H. H. BENNETT, chief of the Soil Conservation Service; R. Y. TARBETT, sanitary engineer, U. S. Public Health Service; Maj. Gen. EDWARD M. MARKHAM, chief of the U. S. Army Engineer Corps; THOMAS R. TATE, director of the National Power Survey, Federal Power Commission; H. H. BARROWS, professor of geography at the University of Chicago and formerly a member of the Mississippi Valley Committee and the National Resources Committee; EDWARD HYATT, state engineer, California.

National Bureau of Standards.—Mr. E. C. CRITTENDEN, Assistant Director of the National Bureau of Standards, sailed from Baltimore on September 5 to attend a meeting of the advisory committee on electricity appointed by the International Committee on Weights and Measures. This meeting was held at Sevres and Paris the week of September 23. The meeting of the advisory committee was followed by the regular biennial session of the International Committee, of which the American member is Prof. A. E. KENNELLY of Harvard University.

U. S. National Park Service.—Director ARNO B. CAMMERER left Washington in late August for the West, accompanying members of the Committee on Public Lands and Surveys of the Senate on an inspection tour of national park projects. Mr. BEN H. THOMPSON, formerly of the Wildlife Staff and now special assistant to the Director, is accompanying Director CAMMERER on this trip.

Dr. CARL P. RUSSELL, in charge of Eastern Museum Activities of the Service, will leave Washington in late September for a visit to the Field Division of Education at Berkeley, California. Dr. LOUIS SCHELLBACH, Assistant to Dr. RUSSELL, will leave Washington at the same time for Berkeley where he plans to remain to direct museum work in western parks and monuments.

Department of Terrestrial Magnetism, Carnegie Institution of Washington.—The establishment of radio communication over an assumed path greater than half the earth's circumference between the radio station at Washington Grove, Maryland, and the Watheroo Magnetic Observatory operated by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in Western Australia, was reported by the former station on August 21, 1935. Ordinarily communications between the Watheroo Magnetic Observatory and stations in the vicinity of Washington are achieved over paths crossing the Pacific Ocean, some 11,900 miles in length. As the communication referred to above took place between 6:30 and 7:00 P.M., 75th meridian time, it is assumed that the transmission-path was over the eastern portion of the globe, which at that time was in darkness.

H. W. WELLS, observer in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, who for the past three years has been assisting in the program of ionosphere-work at the Huancayo Magnetic Observatory in Peru, returned to Washington on September 5.

NEWS BRIEFS

Sugar cane produces a "virus-paralyzing" substance in its growing tips, which combats the effects of cane mosaic, Drs. E. W. BRANDES and JULIUS MATZ, U. S. Department of Agriculture, reported to the fifth triennial congress of the International Society of Sugarcane Technologists held at Brisbane, Australia, in August. They found that when juice extracted from healthy tissue taken from near the growing tips was mixed with juice from mosaic-sick plants, known to contain the virus, and the mixture then injected into healthy canes, the resulting infection was much less severe than control infections caused by unmixed virus-containing juice.

The Federal study of chronic illness in nineteen "sample" states throughout the country is scheduled to start October 15. The study will be directed by GEORGE ST. J. PERROTT, statistician of the U. S. Public Health Service, under a PWA grant of $3,450,000. Ninety percent of the personnel will be taken from the work-relief rolls of the various states. Some of the information will be obtained from the records of hospitals and sick-benefit associations. The rest will come from a house-to-house canvass of 750,000 families selected as representative of the general population, at various income levels. Besides chronic illness, data will be collected on physical disabilities such as blindness, deafness and loss of limbs. Field headquarters will be in Detroit.

Obituary

WALTER HOUGH, head curator of anthropology at the U. S. National Museum, died at his home, 1332 Farragut Street, N. W., Washington, D. C., September 20, 1935, after a short illness. He was born April 23, 1859, at Morgantown, W. Va. After graduating from the University of West Virginia in 1883, he taught in a boys' school at Alton, Ill., until 1886, when he became an aid in the division of ethnology at the National Museum, rising eventually to the position of head curator of anthropology in 1923. He received the Ph.D. degree from his alma mater in 1894 and was elected to membership in Phi Beta Kappa there in 1914.

Doctor Hough conducted numerous explorations in the Southwestern States, Mexico, and other regions in search of archaeological and ethnological data about the American Indian. The results of these and other researches are embodied in many publications, the chief of which deal with such subjects as aboriginal use of fire, history of illumination, primitive armor, Hopi ethnobotany and pigments, Malayan ethnography. Doctor Hough was twice president of the Anthropological Society of Washington. He was also a member of the Washington Academy of Sciences, American Association for the Advancement of Science, Société d'Anthropologie, Swedish Society of Anthropology and Geography, and a Knight of the Order of Isabella of Spain.

ERNST GEORG FISCHER, formerly chief of the Instrument Division of the Coast and Geodetic Survey, died at Garfield Hospital, Washington, D. C., September 22, 1935. He was born at Baltimore, Md., August 6, 1852. At the age of two he was taken to Dresden, Germany, where he attended elementary schools and studied and worked as an engineer until 1870. He then returned to America taking up private engineering practice. In 1887 Mr. Fischer entered the Instrument Division of the Coast and Geodetic Survey and served as the Chief of this Division until his retirement in 1932. In 1934 the Franklin Institute of Philadelphia awarded him the Howard M. Potts gold medal for "a lifetime spent with marked success in the design of instruments of precision for the United States Coast and Geodetic Survey." A list compiled in 1922 contains 24, including tide gauges, artificial horizon, geodetic level, transit micrometer, pressure sounding tube and most remarkable of all, a tide-predicting machine, which won for him widespread recognition. Mr. Fischer was a member of the Washington Academy of Sciences, the Philosophical Society, the Society of Washington Engineers and the Cosmos Club.